Monitoring, evaluation and reporting program

Assessing the sustainability of native fauna in NSW

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1. Introduction

The world is experiencing a rapid loss of biodiversity including an unprecedented rate of species extinction (Lawton & May 1995; Pimm et al. 1995; Baillie et al. 2004). Many if not most of these losses have been attributed to human activity, especially the introduction of invasive species to new islands and continents, the destruction and fragmentation of habitat, over-exploitation and their interactions (Atkinson 1989; Diamond 1989; Mack et al. 2000). The Convention on Biological Diversity was opened at the United Nations Conference on Environment and Development in Rio de Janeiro in 1992 with the objective of preventing further losses (www.cbd.int). In particular, the Convention seeks to reduce the rate of biodiversity loss at global, national and regional scales. One-hundred and sixty-eight nations, including Australia, have signed the Convention.

Consistent with the intent of the Convention, the NSW Government has set state-wide natural resource management (NRM) targets for the conservation of biodiversity. These targets relate to the extent and condition of native vegetation, the sustainability of native fauna species, the recovery of threatened species and the impact of invasive species.

This report details the data sources and analyses used to measure the sustainability of species of native fauna in NSW for the purposes of measuring progress towards the fauna target:

'By 2015 there is an increase in the number of sustainable populations of a range of native fauna species'.

The specific objectives of this report are to:

1. estimate the extent of past losses of native fauna in NSW
2. identify monitoring programs and other data that could be used to measure the sustainability of species of native fauna in NSW
3. undertake an initial assessment for each species for which there are adequate data
4. trial new programs designed specifically to measure the sustainability of native fauna with an emphasis on species and areas that are data poor
5. recommend a package of new and existing programs that will provide adequate monitoring of the sustainability of native fauna in NSW.

Analyses were conducted at both state and regional scales. Regional analyses aligned with the 13 regions established by the NSW and Australian Governments to facilitate NRM (www.nrm.gov.au/nrm/region.html). The results have been reported in the NSW State of the Environment (SOE) 2009 report (www.environment.nsw.gov.au/soe/soe2009/index.htm) and State of the catchments (SOC) 2010 reports (www.environment.nsw.gov.au/soc/stateofthecatchmentsreport.htm).

1.1 Inclusions and exclusions

Given the scale of the task, analyses were restricted to native terrestrial vertebrates. Native terrestrial vertebrates are defined here as those species of vertebrate that live or did live on land within NSW (including islands), excluding species introduced by humans. It includes many species of mammals, birds, amphibians and reptiles but excludes all fish. It includes those aquatic (freshwater and marine) species and pelagic birds that nest on NSW lands. It includes migratory species, but excludes those species that appear to be irregular and infrequent visitors to NSW (vagrants).

To generate a list of native terrestrial vertebrates for NSW and for each of the 13 NRM regions, species records were sourced from the Atlas of NSW Wildlife and the Atlas of Australian Birds (www.birdsaustralia.com.au/our-projects/atlas-birdata.html). The Wildlife Atlas includes unrestricted data (http://wildlifeatlas.nationalparks.nsw.gov.au/wildlifeatlas/watlas.jsp) and licensed data from the Australian Museum, Commonwealth Scientific and Industrial Research Organisation (CSIRO), Forests NSW and other sources. The number of vertebrate species with at least one record in NSW (or the relevant region) was counted, except where there was no evidence that the species was extant post-European settlement (eg fossilised records only). Introduced and vagrant species were identified and excluded. Sub-species were not counted separately to species. All species were then reviewed and a small number excluded on the basis that the records were likely wrong and the species never occurred in NSW. A further 11 species with no Atlas records in NSW were added as they are listed as presumed extinct under the *Threatened Species Conservation Act 1995*. A total of 897 terrestrial vertebrate species native to NSW were thus identified (Table 1; Appendix 1).

Table 1: Numbers of native terrestrial vertebrate species recorded in NSW and in each of the 13 NRM regions since European settlement

NRM region	Amphibians	Birds	Mammals	Reptiles	Total
Western	29	303	61	117	510
Lower Murray Darling	13	290	60	89	452
Border Rivers–Gwydir	47	332	78	121	578
Namoi	37	323	83	111	554
Central West	44	350	81	126	601
Lachlan	37	333	67	117	554
Murrumbidgee	37	347	71	104	559
Murray	26	320	65	76	487
Northern Rivers	61	410	86	128	685
Hunter–Central Rivers	55	403	83	117	658
Hawkesbury–Nepean	51	382	80	93	606
Sydney Metropolitan	37	384	62	64	547
Southern Rivers	43	373	74	75	565
NSW	**83**	**452**	**138**	**224**	**897**

2. Historical declines of native fauna in NSW

At least 34 species of native fauna have become extinct in Australia since European settlement, while many others have suffered substantial reductions in distribution (www.environment.gov.au/cgi-bin/sprat/public/sprat.pl). Losses have been particularly severe among small to medium-sized (35–5500 g) non-flying mammals (Burbidge & McKenzie 1989; Dickman et al. 1993; Johnson & Isaac 2009), although significant losses of birds and amphibians have also been reported (Smith et al. 1994; Kingsford & Thomas 1995; Campbell 1999). Almost half of all extinctions of mammals recorded worldwide in the last 200 years were Australian species (Johnson 2006). The introduction of exotic predators (cats, foxes and rats), herbivores (rabbits, goats and sheep) and diseases, clearing of native vegetation, changes to water flows and changes to fire regimes are likely to have been the major causes of faunal declines (Burbidge & McKenzie 1989; Morton 1990; Dickman 1996; Smith & Quin 1996; Kinnear et al. 2002).

Given the severity of these losses, an analysis of vertebrate declines in NSW provides an important historical context to their current status. While historical loss does not necessarily imply a high risk of extinction (see discussion of depleted species in IUCN 2008), it may be important where the causes of previous declines may not have ceased (including any lag effects) or may not be understood. Loss of distribution over long timeframes is more reliably assessed than current trends for many species. Moreover, loss of distribution of widespread species may have profound impacts on biodiversity and ecosystems more generally (Gaston & Fuller 2008).

2.1 Estimating distribution loss from species records

Estimating distribution loss from species records has been done previously for native vertebrates across Australia (Burbidge & McKenzie 1989) and for some taxonomic classes at a regional scale (eg Dickman et al. 1993). Such reviews have required considerable effort to source information on species distributions from the literature and, given a limited amount of historical data, have limited themselves to coarse estimates of change only. The establishment of databases such as the Atlas of NSW Wildlife and the standardisation of measures of distribution (eg Burgman & Fox 2003; IUCN 2008) are likely to improve the reliability and precision of such estimates.

To estimate distribution loss for NSW vertebrates, records of native vertebrates were sourced from the Atlas of NSW Wildlife and the Atlas of Australian Birds (as above). Records from the Atlas of NSW Wildlife coded as 'rejected' or 'suspect' were not included. Moreover, given the limited reliability and short history of microbat records sourced from ultrasonic detectors (eg Anabat), microbat records were included only where the animals were likely to have been handled directly. In particular, only records with an observation type of 'trapped', 'netted', 'road-kill', 'shot', 'cat-kill', 'dog-kill', or 'dead' were used.

Records were divided into two time periods to describe historic and current distributions of species. Pre-1996 records were used to map historic distributions, while post-1995 records were used to map current distributions. Records from either time interval that were not based on the presence of a living or recently living animal were deemed to be historic records (eg sub-fossil records) and included in the pre-1996 data. Records that could not be reliably assigned to either time period were not used.

Numerous metrics are available for associating an area with a set of point locations, such as species records. Two different metrics were used here, based on the methods recommended by the IUCN for assessing extinction risk of species (IUCN 2008). These were the extent of occurrence and the area of occupancy.

The extent of occurrence is the area encompassed by drawing the shortest possible boundary around the locations where a species has been detected (IUCN 2008; Figure 1a). It was calculated using the α-hulls method (Burgman & Fox 2003), which allows for discontinuities in the distribution of a species. First, α-hulls were calculated for each species using records for both time periods combined, by setting the discontinuity parameter (α) equal to three (as recommended in Burgman & Fox 2003). This parameter determines the maximum distance between records included in the calculation of area and is measured in units of the mean distance between records. Next, α-hulls were calculated for each of the two time intervals, using the same maximum distance between records as used for the time periods combined. This approach reduces the bias in estimating changes in range size where there are likely to be differences in sampling effort between time periods (IUCN 2008). Calculations were done using code supplied by Burgman (pers. comm.) and Penman (pers. comm.) for the statistical package R.

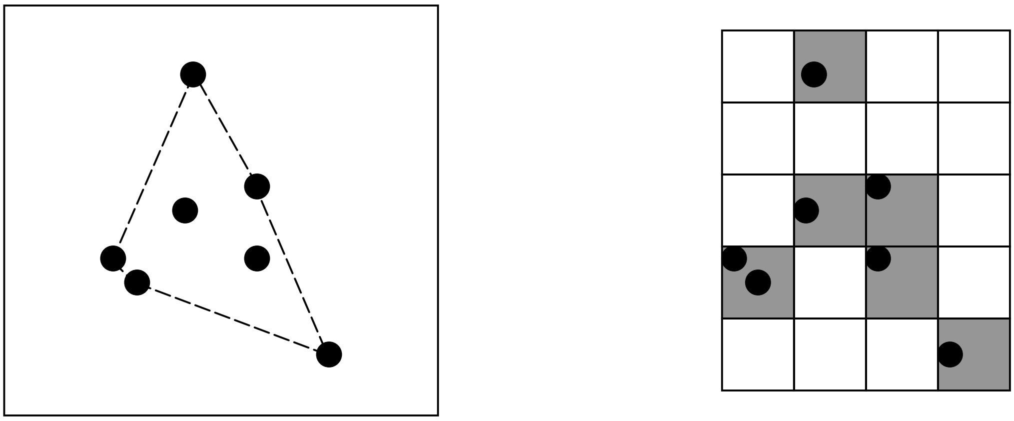


Figure 1: Species distribution as measured by extent of occurrence (a) and area of occupancy (b)

Note: Dots represent records of a species. The extent of occurrence is the area enclosed by the dashed line. The area of occupancy is the area of the squares within which the records occur.

The area of occupancy is calculated by summing the area of all cells occupied by records of a species in a uniform grid that covers the distribution of that species (IUCN 2008; Figure 1b). The area of occupancy is sensitive to the size of the grid cells used in the analysis (IUCN 2008). Thus the IUCN recommend a 2 x 2 km cell for calculating an *absolute* value for area of occupancy when assessing extinction risk against their criteria. However, the objective here was to calculate the *ratio* of areas between two time intervals (current and historic). A fine-scale grid may be unreliable for widespread species, especially where there are large differences in the number of records between time periods. For example, a widespread species undergoing range contraction may occupy fewer large cells over time, but more fine-scale cells if search effort is increasing. Conversely, a coarse-scale grid may have insufficient resolution to assess changes in localised species.

To assess changes in area of occupancy for NSW vertebrates, different cell sizes were chosen for each species so that their distributions were examined with similar levels of resolution. First, species records for both time periods combined were mapped on a grid covering all of NSW (Lamberts projection, False Easting: 9300000.00, False Northing: 4500000.00, Central Meridian: 147.00, Standard Parallel 1: -30.750, Standard Parallel 2: -35.750, scale factor: 1.00, latitude of origin: -33.250, linear unit: Metre, datum GDA 94; the origin of the grid was 8700000, 4020000). Second, the number of cells occupied by records was counted for each of seven different grid sizes (1 x 1 km, 2 x 2 km, 5 x 5 km, 10 x 10 km, 20 x 20 km 40 x 40 km, 80 x 80 km). Third, one cell size was chosen for each species so that the number of cells occupied by combined records was as close to 50 as possible. Area of occupancy was then calculated using the chosen cell size for each of the two time periods. In this way, widespread species were examined with a coarse-scale grid, while localised species were examined with a fine-scale grid.

Distribution loss was calculated for each species as:

$$(\Delta D) = 1 - (\text{current distribution}/\text{historic distribution})$$

using both extent of occurrence and area of occupancy. Distribution loss was defined to be the greater of that estimated by the two metrics. By definition, species with no records post-1995 will have $\Delta D=1$, species whose current and historic distribution are equal will have $\Delta D=0$, and species whose current distributions are larger than their historic ones will have $\Delta D<0$.

Distribution loss was calculated at the state scale using all records within NSW, with the exception of those exclusions described previously. Distribution loss was calculated at the regional scale by intersecting the extent of occurrence and area of occupancy for each time period drawn at the state scale with each NRM region that contained at least one record of that species.

2.2 *Reviewing estimates of distribution loss*

Estimating distribution loss from species records may be unreliable if there are differences in sampling effort, sampling uniformity and spatial accuracy of records between time intervals (Burgman & Fox 2003). Estimates of change may also be doubtful if distributions are distorted excessively by erroneous records. Here, records pre-1996 and post-1995 were deemed sufficient to map the historic and current distributions of most species approximately. However, there are likely to be differences in sampling effort, sampling uniformity and record accuracy between these time periods for most species. For example, there were many more post-1995 records in the Atlas of NSW Wildlife than pre-1996 for each of the vertebrate classes (amphibians, birds, mammals and reptiles), likely reflecting a substantial increase in overall survey effort driven by threatened species and other environmental legislation. Moreover, there were few pre-1980 records (the year in which the Atlas of NSW Wildlife commenced) and hence pre-1995 records of species that suffered early declines are likely to be a non-uniform sample of their historic distributions. Some of these biases may have been reduced (but not eliminated) by the use of α-hulls with fixed maximum distances between points and the flexible approach to cell size (see above). Other problems remain however, especially with species that have undergone recent changes in taxonomy and species that require specialised detection techniques (eg microbats). Little or no historic data may be available for these species, while available data may be misleading.

Given these potential problems, a series of filters was applied in an attempt to identify those species for which records were likely to give unreliable estimates of change. First, species that have undergone taxonomic revision were identified. Distribution loss was scored as unknown for those species where many of the records were likely to be unreliable. Second, species with less than 50 historic records were identified. Distribution loss was scored as unknown for those species where there were grounds to question either the reliability or adequacy of historic records.

Estimates of distribution loss at the state scale were then compared to expert opinion. Following the methods of Lunney et al. (2000), species experts were asked to estimate long-term change (ie European settlement to date) in distribution using the scoring system shown in Table 2. Between one and seven responses (mean number of responses 2.1) were obtained for 879 of 897 species identified. Many of the responses were intermediate scores not defined in the scoring system; these were interpreted as a combination of categories (see Table 2). Median scores were then calculated for all species. Values from Lunney et al. (2000) were included if and only if a unique median could not be calculated. Species whose estimated distribution loss (ΔD) at the state scale differed significantly from expert opinion were identified and, in most cases, distribution loss was scored as unknown.

Given the enormity of the task, expert opinion on distribution loss at the regional scale was not sought (over 7000 combinations of species and NRM regions). Hence regional estimates were not subject to an expert opinion filter. However, regional loss was defined to be equal to distribution loss estimated at the state scale where the number of historic records within the region was less than 50.

Table 2: The scoring system used for expert review of distribution loss (ΔD) in native terrestrial vertebrates, following Lunney et al. 2000

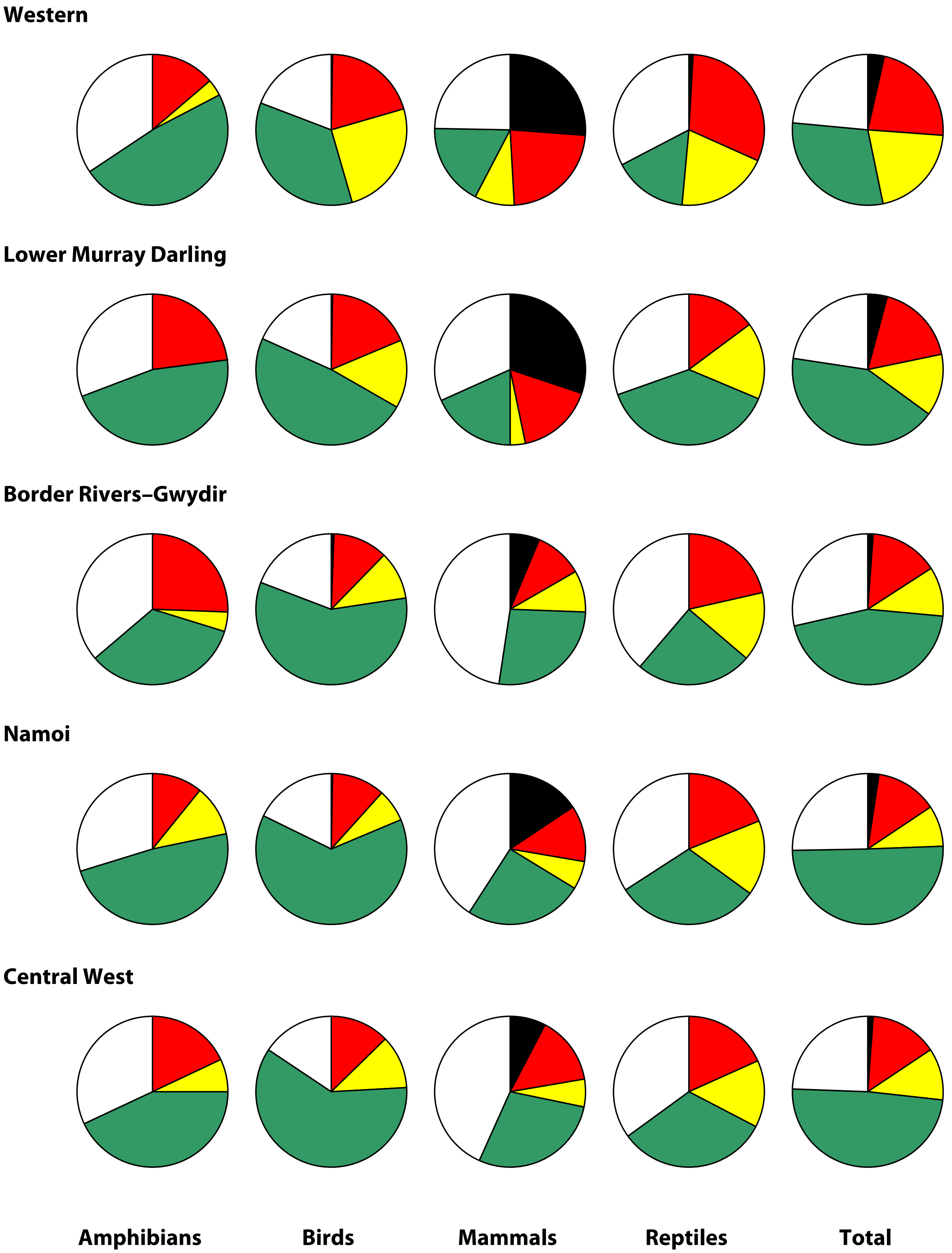
Score	Change	Acceptable estimates of ΔD from records
20	Area has declined by 76–100%	0.625–1
17–19	Undefined in Lunney et al. 2000, but interpreted as 51–100%	0.5–1
16	Area has declined by 51–75%	0.375–0.875
13–15	Undefined in Lunney et al. 2000, but interpreted as 26–75%	0.25–0.75
12	Area has declined by 26–50%	0.125–0.625
9–11	Undefined in Lunney et al. 2000, but interpreted as 1–50%	0.01–0.5
08	Area has declined by an unknown extent	0.01–1
5–7	Undefined in Lunney et al. 2000, but interpreted as 1–50%	0.01–0.5
04	Area has declined by 1–25%	0.01–0.375
1–3	Undefined in Lunney et al. 2000, but interpreted as 0–25%	0–0.375
00	Area increasing or unchanged	≤0.125

2.3 Results

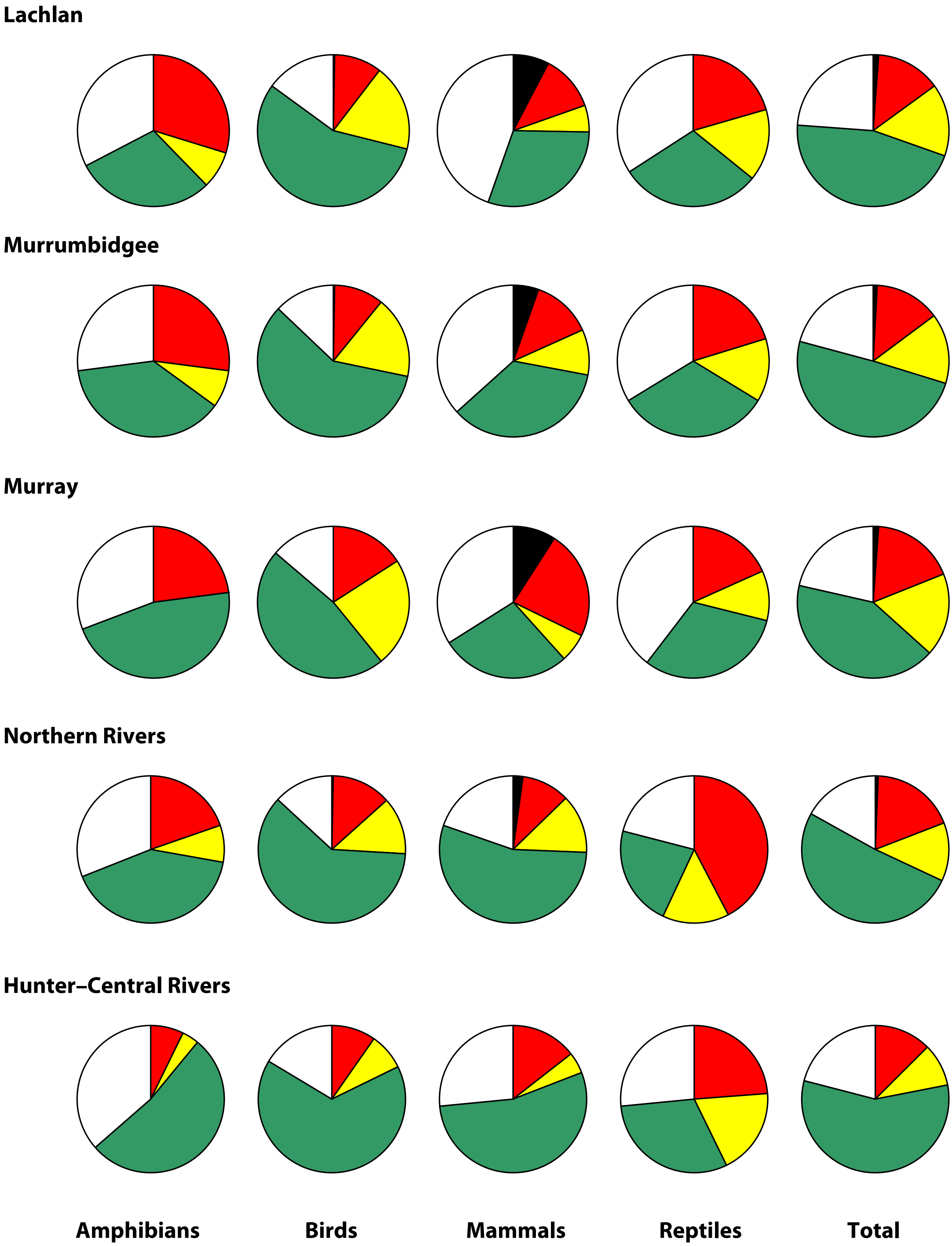
Distribution loss was estimated for 455 of 897 species (51 per cent) of native terrestrial vertebrates at the state scale (Figure 2; Appendix 1). Thirty-eight species (four per cent) were listed as presumed extinct under the *Threatened Species Conservation Act 1995.* A further 60 species (seven per cent) were estimated to have lost at least half of their pre-European distribution. Losses appear to have been greatest among mammals, with 26 of 138 species (19 per cent) listed as presumed extinct and a further 14 species (10 per cent) having lost at least half of their former range. Most of these species are or were small to medium-sized ground-dwelling mammals. However, distribution loss could not be estimated reliably for many flying mammals (ie bats). All other taxonomic groups have experienced some severe declines, although no extinctions of amphibians have been recorded.

Distribution loss was estimated for a higher proportion of species at the regional scale (mean: 77 per cent for 13 regions) reflecting the absence of an expert opinion filter at this scale. Across regions, declines in native terrestrial vertebrates were most apparent in western NSW. In the Western region, 18 of 510 species (four per cent) were listed as presumed extinct, while a further 115 species (23 per cent) were estimated to have lost at least half of their pre-European distribution. In the Lower Murray Darling region, 19 of 452 species (four per cent) were listed as presumed extinct, while a further 79 species (17 per cent) were estimated to have lost at least half of their pre-European distribution. Again, mammals have fared particularly poorly with almost half of the species in both regions either listed as presumed extinct or estimated to have lost at least half of their former range. No extinctions have been recorded among any Hunter–Central Rivers species.

Figure 3 illustrates the estimation of distribution loss at the state scale using the two metrics. There were 661 records of the green and golden bell frog (*Litoria aurea*) pre-1996 and a further 1644 records post-1995. The extent of occurrence estimated from α-hulls declined approximately 80 per cent from about 47,500 km^2 to about 9500 km^2. The area of occupancy estimated using a 40 km grid cell declined from 61 cells to 29, or about 52 per cent. Four of five experts who estimated distribution loss for this species suggested a 51–75 per cent decline in distribution. An estimated distribution loss of 80 per cent was accepted for this species on the basis that the majority of records were likely to be reliable taxonomically, there were adequate historic records and the estimate was not significantly different from expert opinion. Thus the species is included in Figure 2 as having suffered a severe decline $\Delta D \geq 50$ per cent at the state scale.



Shown are the proportion of species in each of five categories: presumed extinct ■, severe decline ΔD ≥ 50 per cent ■, moderate decline 50 per cent > ΔD ≥ 25 per cent ■, no significant decline ΔD < 25 per cent ■ and data deficient □. The numbers of species in each figure are given in Table 1.



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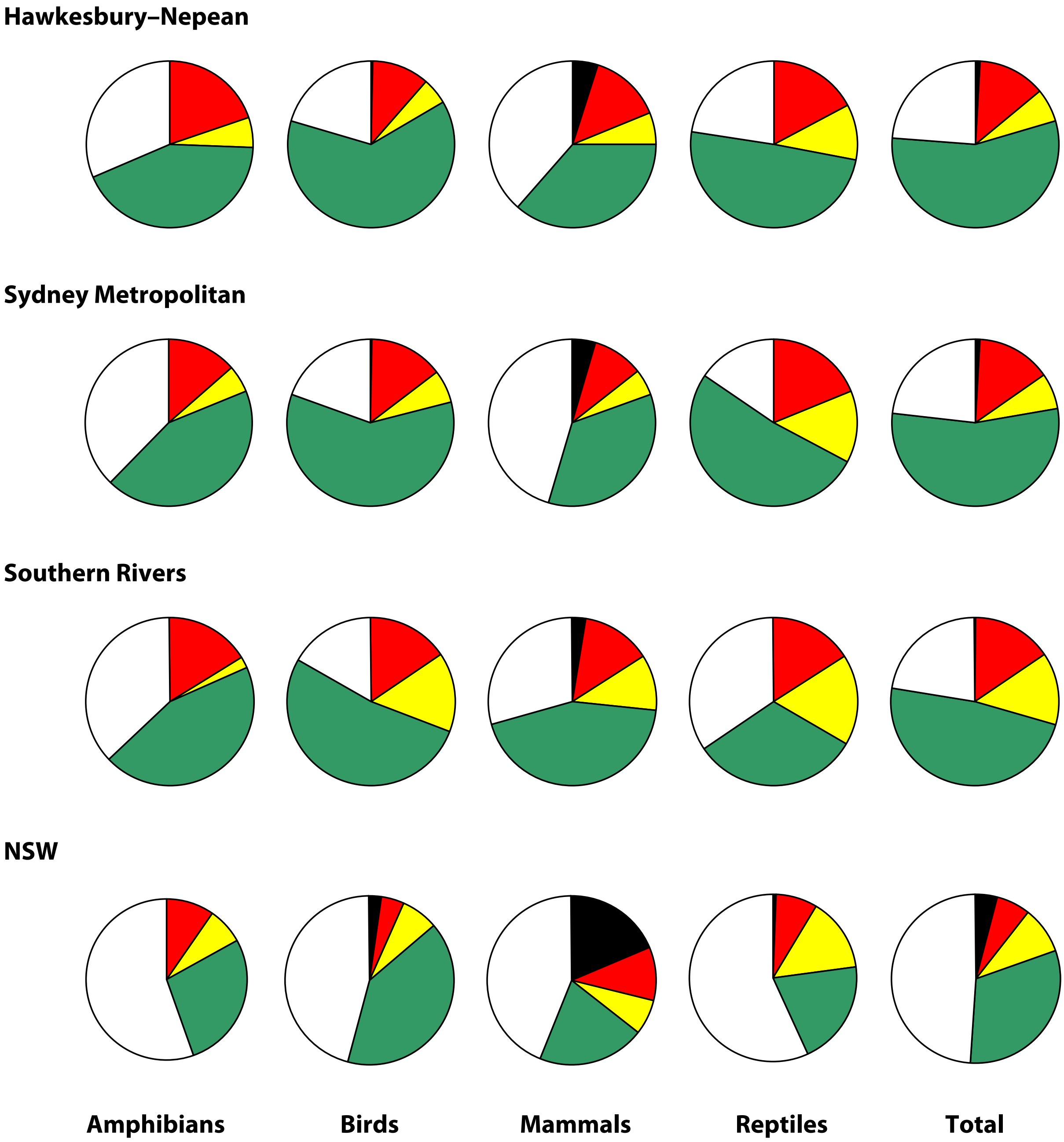


Shown are the proportion of species in each of five categories: presumed extinct ■, severe decline ΔD ≥ 50 per cent ■, moderate decline 50 per cent > ΔD ≥ 25 per cent ■, no significant decline ΔD < 25 per cent ■ and data deficient □. The numbers of species in each figure are given in Table 1.

Figure 2: Distribution loss since European settlement of native terrestrial vertebrates in NSW and in each of the 13 NRM regions

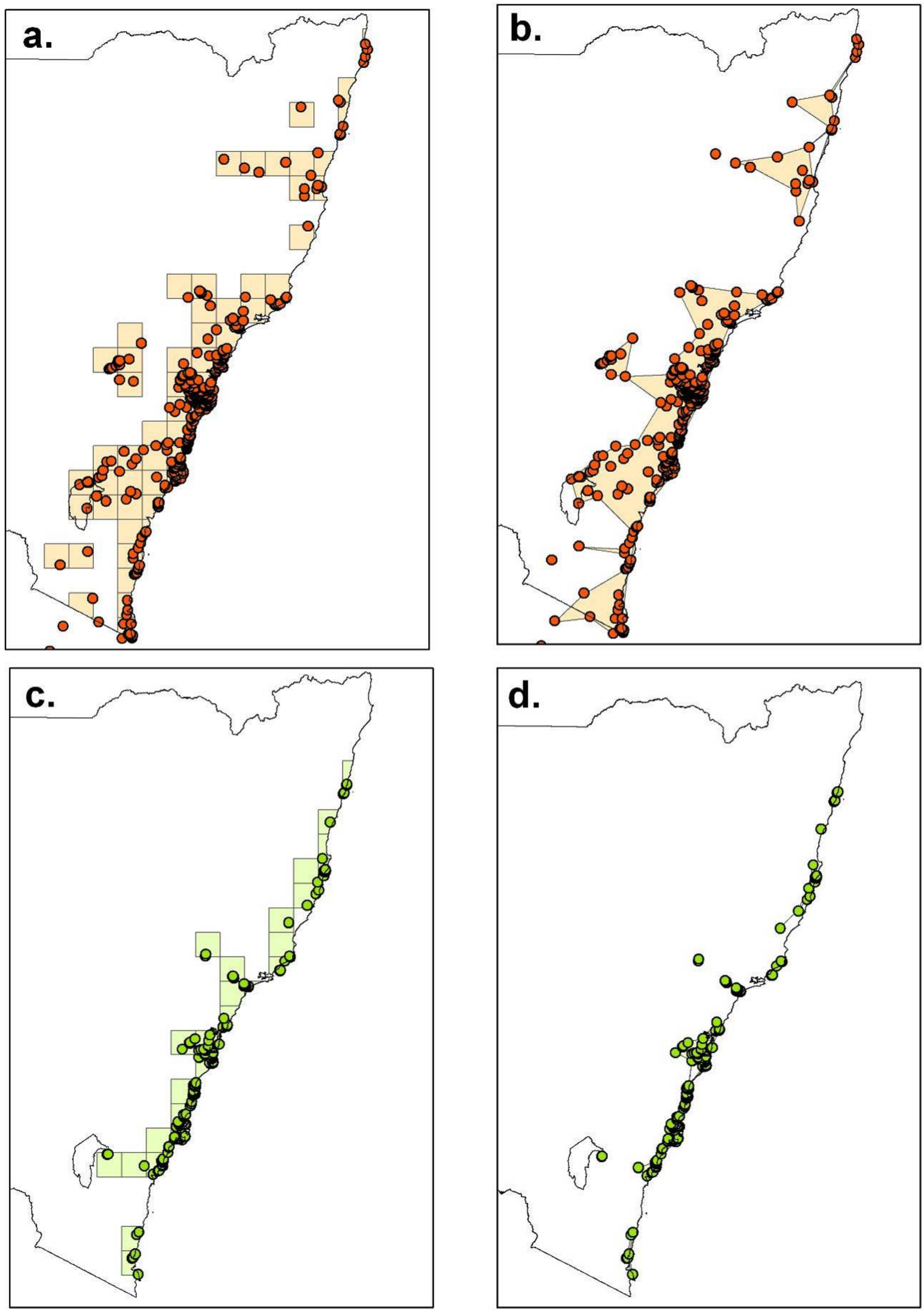


Figure 3: Estimation of distribution loss for the green and golden bell frog (*Litoria aurea*) in NSW

Note: Figures a and b show occupied grid cells (area of occupancy) and α-hulls (extent of occurrence) for pre-1996 records (historic). Figures c and d show the equivalent for post-1995 records (current). Estimated loss was 52 per cent and 80 per cent by the two methods respectively.

3. The sustainability of native fauna in NSW

The state-wide NRM target for native fauna states:

'*By 2015 there is an increase in the number of sustainable populations of a range of native fauna species'*.

Sustainability is defined here as the probability of a species or population remaining extant within a given area after a given time. Intuitively, it is negatively related to extinction risk. The IUCN has developed criteria for assessing the extinction risk of species at both global (IUCN 2001, 2008) and regional scales (IUCN 2003). These are often referred to as the Red-List criteria. In brief, the criteria score extinction risk based on estimates of population size, area of distribution, trends in population size or area of distribution over time and direct estimates of extinction risk from demographic modelling. Where species are assessed over part of their distribution only (regional assessment), scores may be upgraded or downgraded depending on the likelihood of significant immigration from outside the region.

For the purposes of reporting against the state-wide NRM target, *population* is defined as the NSW or NRM region's population. Assessing the extinction risk of populations at finer scales is of limited value as the risk of extinction of any localised population is intrinsically high. For example, a localised but otherwise stable population may become extinct at any time due to unforeseen events (eg bushfire, land clearing). Monitoring a local population also implies little about the sustainability of the species more generally.

It is not the intent of this report to assess extinction risk for all species of native fauna using all available information; this is the purpose of the determinations made under the *Threatened Species Conservation Act 1995*. Rather, only those species that are monitored sufficiently to measure changes in extinction risk reliably have been considered. Given that such monitoring may be difficult and expensive, it may be appealing to identify a few species to monitor that might indicate trends across broad groups of fauna (indicator species; Caro & O'Doherty 1999). However, identifying indicator species is challenging as relationships between species and how they respond to various environmental pressures is rarely known, such that the basis for assuming that trends in one species are indicative of trends in another is often unclear (eg Landres et al. 1988). Irrespective of these theoretical arguments, long-term (eg ≥ 10 years) monitoring is required to assess the sustainability of most species and so any baseline assessment must be based on existing data. Thus we considered all species for which adequate data were available.

3.1 Assessing sustainability using modified IUCN Red-List criteria

The sustainability of native terrestrial vertebrate species in NSW was assessed using the IUCN Red-List criteria with minor modifications. These modifications involved changes to category names so they better relate to sustainability, simplified time intervals for calculating trends, establishment of quantitative thresholds for the IUCN category *near threatened* and the addition of a sub-criterion so that currently-declining species that have also suffered severe loss of distribution since European settlement are scored as less sustainable. The criteria are detailed in Appendix 2.

Sustainability was assessed using the same number of categories and category thresholds as is extinction risk under the IUCN Red-List criteria. However, given that the objective was to assess sustainability and not extinction risk per se, different category names were used (see Table 3). Here, only species in the first category were defined as sustainable, with species in each subsequent category being at an increasing risk of extinction. These categories were renamed again in the SOC 2010 reports (Table 3) so that standardised nomenclature was used to define condition across all of the NRM targets (see Section 1).

Table 3: IUCN categories for extinction risk and the equivalent sustainability categories used in the SOE 2009 and SOC 2010 reports

IUCN category	Sustainability	SOC 2010 reports
Least concern	Sustainable	5 Very good
Near threatened	Low risk	4 Good
Vulnerable	Moderate risk	3 Fair
Endangered	Substantial risk	2 Poor
Critically endangered	Severe risk	1 Very poor
Presumed extinct	Extinct	0 Extinct
Data deficient	Data deficient	Data deficient

Under the IUCN Red-List criteria, the timeframe for assessing change in distribution and population size may vary with the generation length (mean age of the parents of the current cohort) of the species (IUCN 2008). Under Criterion A for example, declines are calculated over the longer of 10 years or three generations and then compared to a series of thresholds to determine extinction risk. Ten years is set as the lower limit for calculating change on the basis that it is the shortest period relevant to conservation planning. Given the large number of species to be assessed here however, ten years was used for all species assessed under this criterion. This may be appropriate for most native vertebrates as most are likely to have generation lengths ≤ three years. The sustainability of species with longer generation lengths may have been overestimated however, as any declines should have been calculated over longer time intervals. The lower limits were likewise used in other criteria requiring the estimation of change over time.

The IUCN Red-List criteria do not include explicit thresholds to differentiate the category *near threatened* from *least concern*. Hence quantitative thresholds were chosen here to partition the *low risk* and *sustainable* categories. These thresholds were somewhat arbitrary, but were typically half or double the equivalent thresholds between *low risk* and *moderate risk* as appropriate.

The analyses in Section 2 suggest that many native terrestrial vertebrates have suffered severe range loss since European settlement. Such declines may be reliable predictors of extinction risk where the causes of previous declines may not have ceased (including any lag effects) or may not be understood. An additional sub-criterion was added so that species that have previously lost more than 50 per cent of their distribution were assigned to the next lowest sustainability category. For example, a species that would be assigned to category 3 (*moderate risk)* based on a decline over the last ten years, would be assigned to category 4 (*substantial risk)* if it was estimated to have lost more than 50 per cent of its historic range, and if the likely causes of that loss had not ceased or were not understood.

Each species was assessed simultaneously across all criteria for which data were available (see below) and scored by the criterion which gave the lowest sustainability (highest extinction risk). With the exception of extinct species, all species assessed at the state scale were subject to the IUCN regional process (Appendix 3) as all also occur outside NSW. Given the large number of combinations of species and NRM regions however, the regional process was not applied to species assessments within NRM regions.

3.2 Data sources and analyses

The sustainability of individual native terrestrial vertebrate species was assessed if and only if the species was being actively monitored at the state or NRM regional scale. In particular, objective data were required on total distribution and population size, trends in distribution and population size over time and/or extinction risk from demographic studies. Given that monitoring programs are rarely designed to measure all variables of interest, species were considered to be monitored adequately if they could be assessed against the most relevant criteria. Thus monitoring of widespread species was considered adequate if there were data to assess trends in distribution and/or population size under Criterion A.

A series of workshops was held throughout NSW in 2007/2008 in an attempt to identify monitoring programs and other potential data sources. While many monitoring programs were documented, few provided adequate spatial sampling of species distributions or adequate temporal sequences that might allow the detection of trends. By far the largest source of information was Birds Australia's Atlas of Australian Birds (www.birdsaustralia.com.au/our-projects/atlas-birdata.html). Since 1998, the presence of individual bird species has been recorded in over 420,000 standardised surveys undertaken across Australia by volunteers. Notwithstanding the potential for sampling bias, these surveys provide a substantial dataset which may allow trends in the abundances of diurnal birds at a regional or larger scale to be inferred (eg Barrett et al. 2007). Data from the Atlas of Australian Birds were sourced from Birds Australia for the whole of NSW for the years 1998–2007 (see further detail below).

Systematic aerial survey of terrestrial wetlands to estimate waterbird populations has been ongoing across much of eastern Australia since 1983 (Kingsford & Porter 2009). These data provide a more robust measure of population trends and hence sustainability for several species of waterbirds. Data from these surveys were analysed for the whole of NSW for the years 1983–2007.

Outside these major programs, the Office of Environment and Heritage (OEH) undertakes a small number of targeted threatened species monitoring programs in collaboration with other NSW Government agencies and researchers. Many of these programs aim to measure the effectiveness of management. For example, under the NSW Fox Threat Abatement Plan, monitoring has been established to measure the responses of targeted threatened species, other native fauna and foxes to fox control in priority areas (Mahon 2009). Such programs may be used to measure sustainability if spatial and temporal sampling of species distributions are adequate. OEH also undertakes broad-scale monitoring of kangaroo species that are subject to commercial harvesting across much of inland NSW.

A summary of data sources used in species assessments is provided in Section 3.3.

The analyses required to assess species against the criteria were limited largely to estimating rates of change in distribution or population size over time using regression (logistic and linear).

Regression analyses were performed using SAS Enterprise Guide 4.1 (SAS Institute 2006). To account for uncertainty, 90 per cent confidence intervals were calculated around the intercept and slope coefficients (Sokal & Rohlf 1995). These estimates were then used to calculate upper, lower and point estimates of change over ten years.

The application of the regression results to Criterion A was made according to decision rules (Figure 4). The decision rules were based on the number of sustainability categories (Table 3) that were spanned by the 90 per cent confidence interval of the calculated percentage change of the population or distribution. The decision rules were:

- if the confidence interval encompassed less than three categories, the point-estimate was used
- if the confidence interval encompassed more than three categories but did not span zero, the point estimate was used
- if the confidence interval encompassed more than three categories and spanned zero, the species was considered to be data deficient for Criterion A.

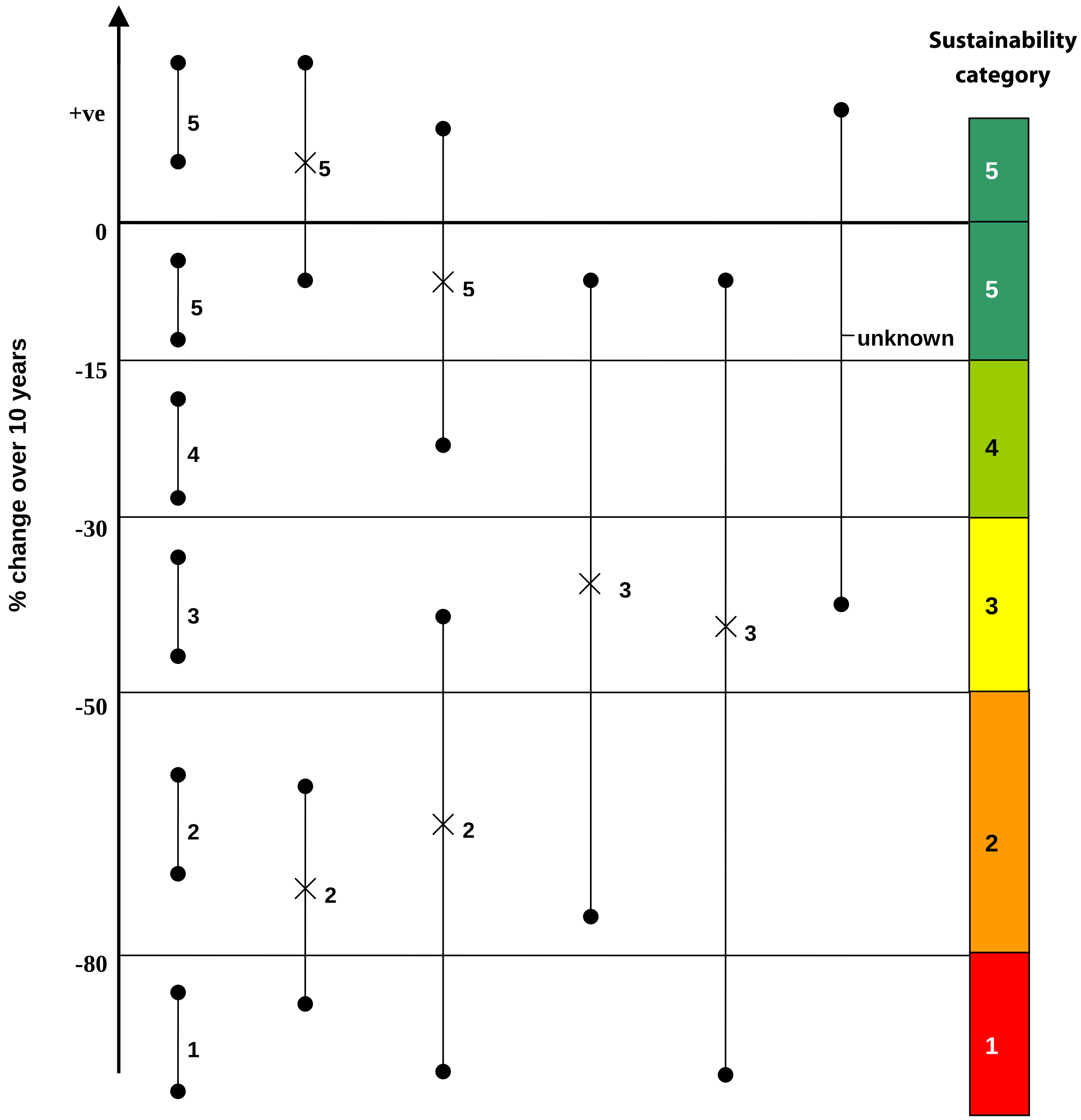


Figure 4: **Decision rules for assigning species to sustainability categories based on the 90 per cent confidence interval of the estimated change in population or distribution over 10 years**

Note: Vertical lines represent the 90 per cent confidence interval, X is the point-estimate and numerals represent the category to be assigned as per Table 3. The two intervals associated with category 5 were treated as separate for the purpose of counting the number of intervals within the 90 per cent confidence intervals. Illustrated for Criterion A(ii).

3.3 Results

Including species listed as presumed extinct, sustainability was assessed for 255 of 897 species (28 per cent) of native terrestrial vertebrates in NSW (Figure 5; Appendix 1). The vast majority of species assessed were birds. Excluding extinct species, 206 of 217 assessable species (95 per cent) were birds, seven (three per cent) were mammals and four (two per cent) were amphibians. Adequate monitoring data were not available for any extant species of reptile. Across taxonomic classes, 139 of 217 extant assessable species had their extinction risk downgraded on the basis of potentially significant immigration from populations in other states; no species had its extinction risk upgraded. Nevertheless, only 42 extant assessable species (19 per cent) were scored as sustainable. This represents less than five per cent of native terrestrial vertebrate species of NSW.

Sustainability was assessed for 9–24 per cent (mean: 13 per cent) of native terrestrial vertebrate species within the 13 NRM regions (Figure 5). Again, the vast majority of assessable species were birds and, with the exception of the extinction of the fierce snake (*Oxyuranus microlepidotus*) from the Western region, no reptile species were assessable in any region. The proportion of extant assessable species that were scored as sustainable varied between two per cent (three of 128) in the Lachlan region and 17 per cent (seven of 42) in the Murray region. Overall, the proportion of native terrestrial vertebrate species scored as sustainable ranged from 0.4 per cent (two of 565) in the Southern Rivers region to 1.8 per cent (12 of 685) in the Northern Rivers region. However, given that these assessments were not subject to the IUCN regional process and that this process resulted in an upgrade of sustainability scores for many species at the state scale, it is likely that the number of sustainable species within each NRM region has been underestimated. Moreover, apparent differences between regions are likely to be an artifact of biases in available data (see Sections 4 and 5 for further discussion).

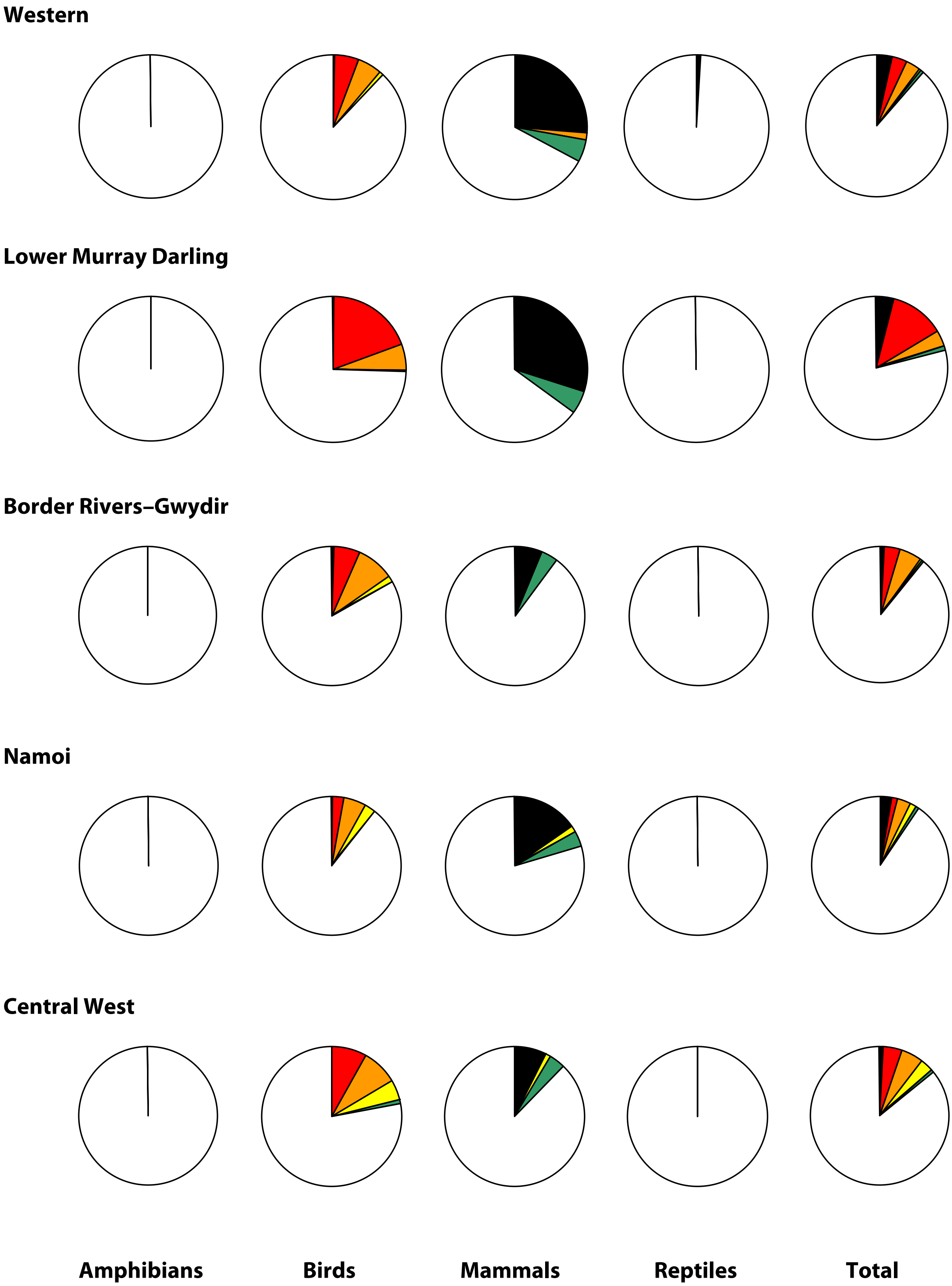
76 per cent of species assessments at the state scale were based on analyses of data from the Atlas of Australian Birds (Figure 6). Aerial surveys of waterbirds accounted for three per cent, targeted monitoring of threatened species five per cent and monitoring for harvesting of kangaroo populations one per cent. Extinct species were identified from the determinations of the NSW Scientific Committee (15 per cent). Data sources for assessments made within NRM regions were similar. Examples of species assessments made from the various data sources are described below.

3.4 Example assessments

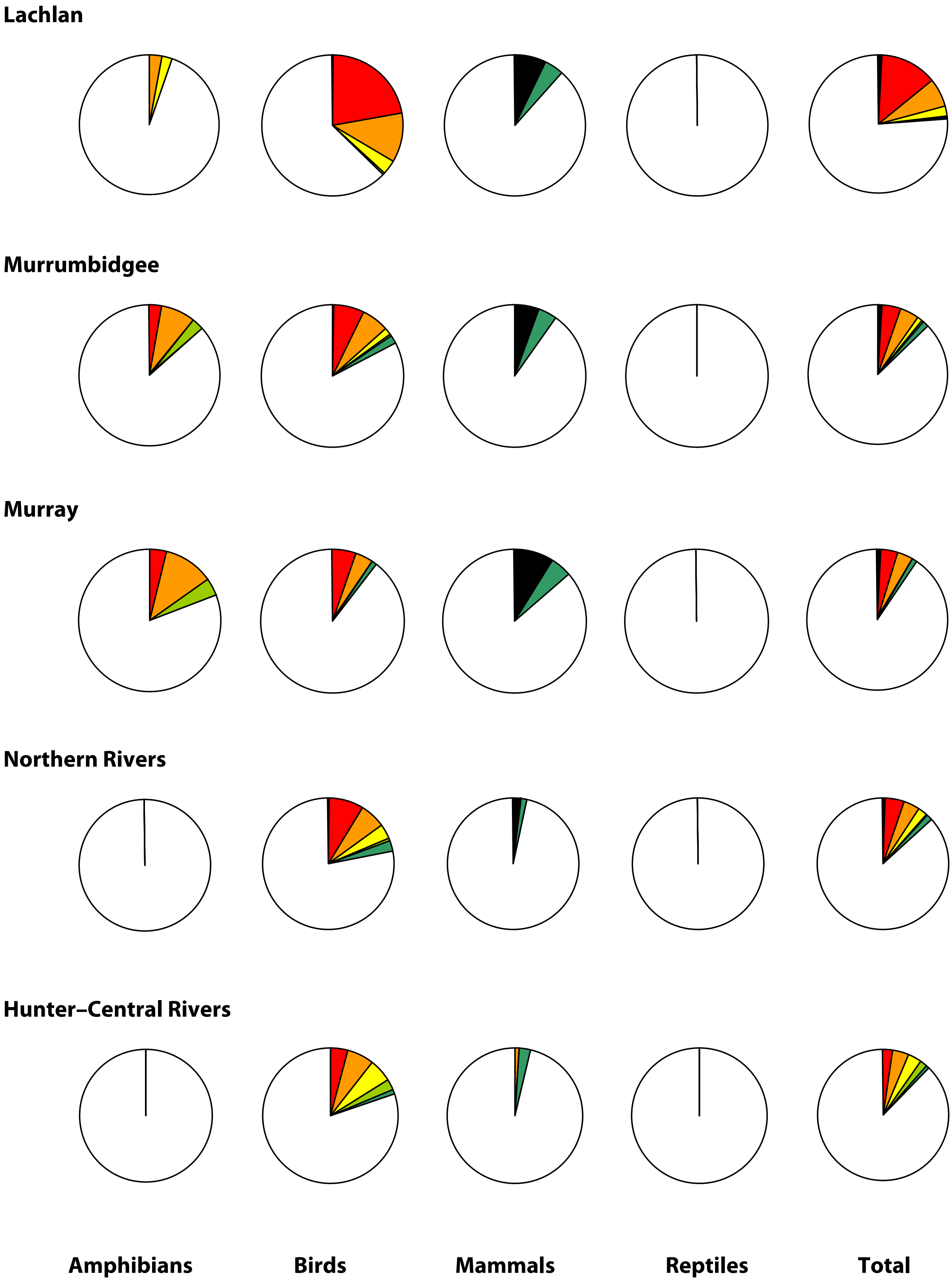
The Atlas of Australian Birds and the superb fairy-wren (Malurus cyaneus)

The Atlas of Australian Birds is a database that contains the results of over 420,000 standardised bird surveys conducted across Australia since 1997. Analyses were restricted to binary data from the two ha 20 minute searches as these were by far the most common in the database. Following Barrett et al. (2007), surveys were partitioned into 10 minute grid cells (GCS Australian 1966; 20 km x 20 km approximately). For each species, the set of all cells in which it was detected in any survey between October 1997 and September 2007 was identified. Changes in the frequency of detection in surveys conducted within these cells over this time interval were analysed by year, season (spring/summer and autumn/winter) and their interaction (year x season) using logistic regression. Change in the frequency of detection over the ten-year interval was estimated from the intercept and year coefficients as discussed in Section 3.2.

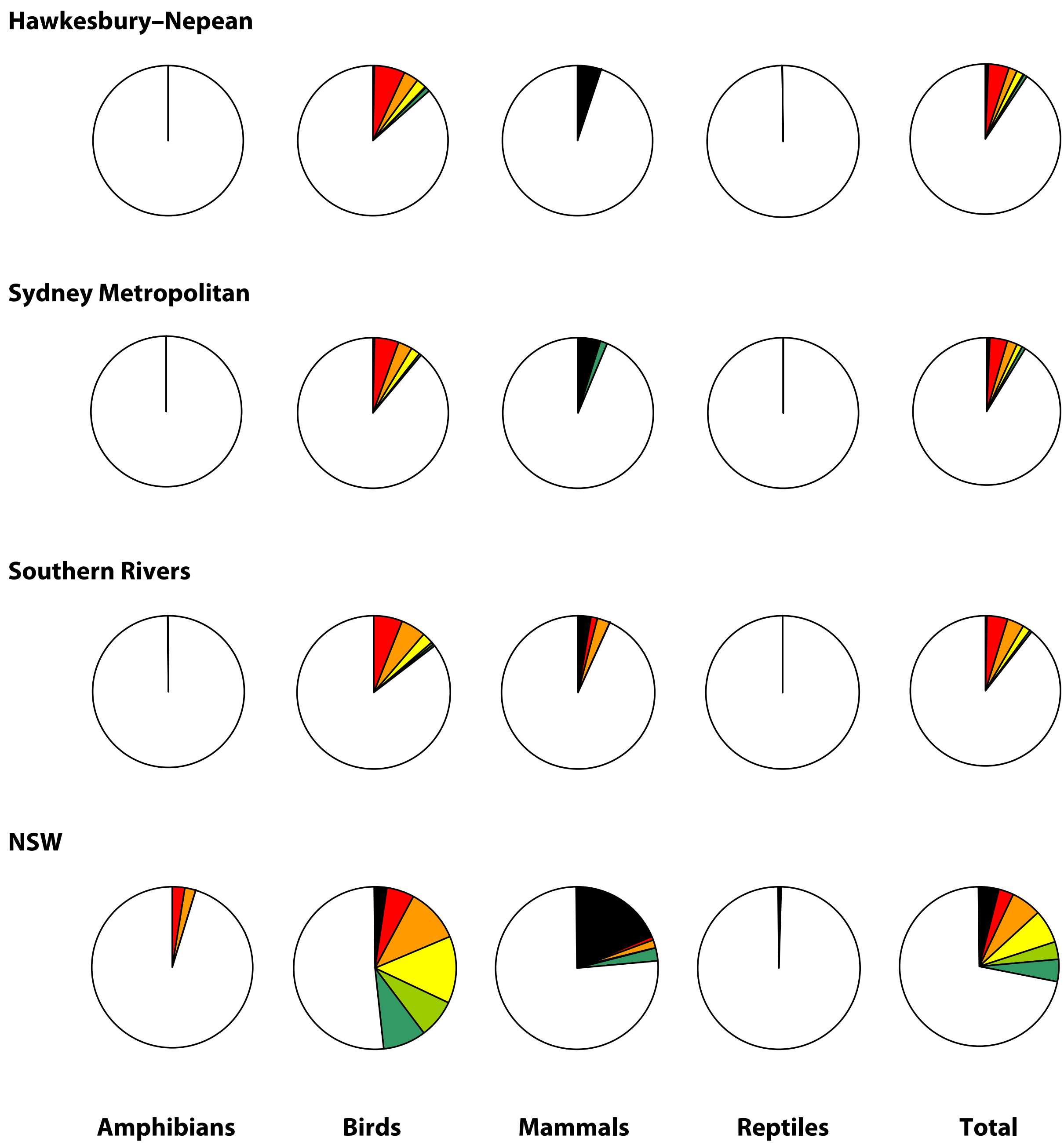
The superb fairy-wren was detected in 9205 of 27,840 surveys conducted over 915 grid cells between October 1997 and September 2007 (Figure 7). The frequency of detection declined significantly over this period (Figure 8). A regression model fitted to these data suggests a decline in the rate of detection of 34 per cent over 10 years (90 per cent confidence limits: -30 per cent to -38 per cent). Converted for the likely asymptotic relationship between abundance and detection rate, the estimated decline in abundance over 10 years is 40 per cent (90 per cent confidence limits: -35 per cent to -44 per cent). Thus sustainability was scored as *moderate risk* under Criterion A2 (Appendix 2). However, given that there is a broad zone of contiguous habitat for this species between NSW, Queensland, Victoria and South Australia, significant immigration from outside NSW was judged likely. In the absence of any specific information to suggest that such immigration may decline, the score was downgraded to *low risk* as per the IUCN regional process (Appendix 3).



Shown are the proportion of species in each of seven categories: presumed extinct ■, severe risk ■, substantial risk ■, moderate risk ■, low risk ■, sustainable ■ and data deficient □. The number of species in each figure is given in Table 1.



Shown are the proportion of species in each of seven categories: presumed extinct ■, severe risk ■, substantial risk ■, moderate risk ■, low risk ■, sustainable ■ and data deficient □. The number of species in each figure is given in Table 1.



Shown are the proportion of species in each of seven categories: presumed extinct ■, severe risk ■, substantial risk ■, moderate risk ■, low risk ■, sustainable ■ and data deficient □. The number of species in each figure is given in Table 1.

Figure 5: Sustainability of native terrestrial vertebrates in NSW and in each of 13 NRM regions

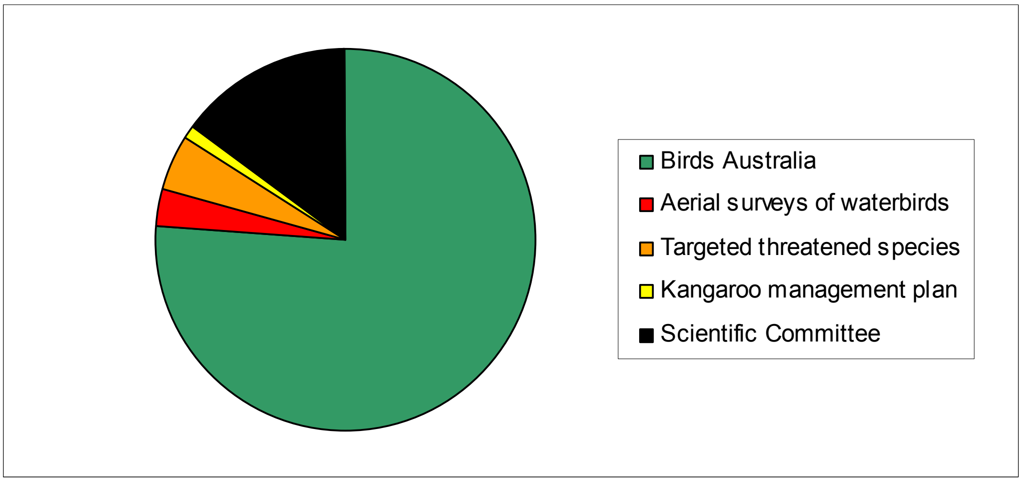


Figure 6: Data sources for sustainability assessments of NSW native terrestrial vertebrates

Note: Extinct species were identified from the determinations of the NSW Scientific Committee.

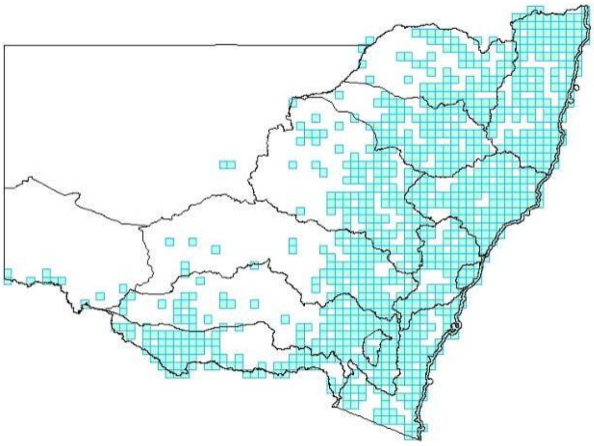


Figure 7: Cells in which the superb fairy-wren (*Malurus cyaneus*) was detected in two ha 20 minute surveys undertaken between spring 1997 and spring 2007

Source: Atlas of Australian Birds

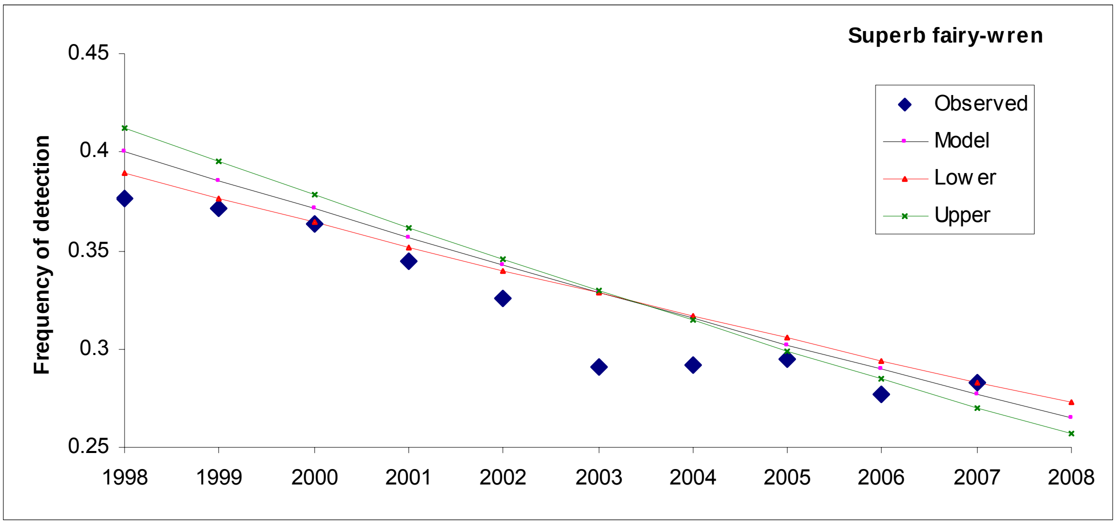


Figure 8: **Observed and modelled frequency of detection for the superb fairy-wren (*Malurus cyaneus*) in two ha 20 minute surveys from across its NSW distribution**

Note: The model shown includes the intercept and year coefficients only.

Source: Atlas of Australian Birds

The NSW Fox Threat Abatement Plan and the brush-tailed rock wallaby (Petrogale penicillata)

The NSW Fox Threat Abatement Plan (NPWS 2001) establishes priorities for fox control across the state by identifying the threatened species at greatest risk from fox predation and the sites at which fox control for these species is most critical. Under the plan, 12 colonies of brush-tailed rock wallaby within the Hunter–Central Rivers region have been monitored since 2003 using pellet counts. Six colonies are subject to fox control, while a further three colonies act as experimental controls. However, initial analyses suggest that fox control has neither reduced fox activity nor increased rock wallaby activity at treatment sites compared to non-treatment sites (Mahon P, unpublished data). The final three monitored colonies lie in more productive habitat in the north of the region and have been subject to various levels of wild dog control. Irrespective of differences in management and habitat, the 12 colonies constitute most of the known rock wallaby sites within the region and hence are likely to be a large indicative sample of the regional population.

A regression model fitted to data combined across colonies predicts a decline in rock wallaby activity of 58 per cent over 10 years (90 per cent confidence limits: -12 per cent to -92 per cent). Thus, sustainability was scored as *substantial risk* under Criterion A2 (Appendix 2). Given that the brush-tailed rock wallaby is a relatively sedentary species and that its distribution within the region is highly fragmented, significant immigration from outside the region is highly improbable. Hence the score was unchanged as per the IUCN regional process (Appendix 3).

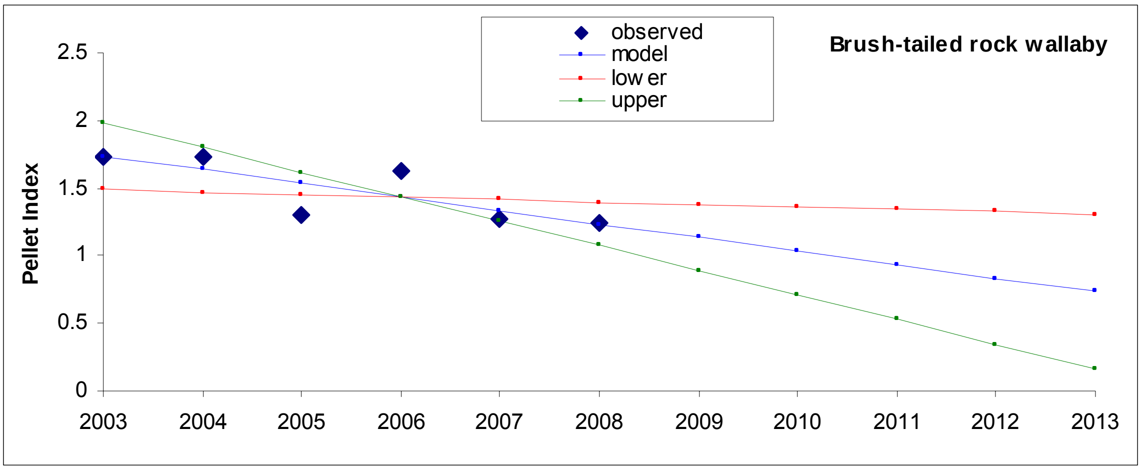


Figure 9: Observed and modelled activity of the brush-tailed rock wallaby (*Petrogale penicillata*) derived from pellet counts from 12 colonies throughout the Hunter–Central Rivers region

Source: NSW Fox Threat Abatement Plan

4. An index of fauna sustainability

For the purposes of the SOC 2010 reports, an index of fauna sustainability was calculated for each NRM region as the mean of the sustainability scores for all species that were able to be assessed. Although scores for individual species are categorical rather than continuous, the mean will reflect net changes in the sustainability of individual species over time. The mean scores were assigned to broad categories for ease of interpretation as shown in Table 4. The results are summarised in Table 5.

Given the limited availability of data however, the index is biased towards those groups of species for which most data were available (diurnal birds). Standard errors were not calculated as the set of species for which data were available was far from a random sample of species within each region. Thus apparent differences between regions may be an artifact of biases in available data rather than reflective of real differences in sustainability. Nevertheless, such a metric may provide a measure of change over time or differences between regions if a larger, more-representative set of species was monitored in the future. Note that scores for NRM regions are likely to be underestimates relative to the state score as species assessed at the regional scale were not subject to the IUCN regional process (see Section 3.3).

Table 4: Thresholds for assigning the sustainability index to a condition category for the SOC 2010 reports

Sustainability index	Condition	Interpretation
5	Very good	All assessable species are sustainable
4≤value<5	Good	Mean sustainability of assessable species is near threatened or better
3≤value<4	Fair	Mean sustainability of assessable species is worse than near threatened
2≤value<3	Poor	Mean sustainability of assessable species is worse than IUCN vulnerable category
<2	Very poor	Mean sustainability of assessable species is worse than IUCN endangered category

Table 5: Fauna sustainability by NRM region calculated for the purposes of the SOC 2010 reports. The index is biased towards those groups of species for which most data were available

Western 1.3	Central West 2.0	Northern Rivers 2.2	Southern Rivers 1.9
Lower Murray Darling 1.1	Lachlan 1.5	Hunter–Central Rivers 2.6	
Border Rivers–Gwydir 1.7	Murrumbidgee 2.1	Hawkesbury–Nepean 1.8	NSW 2.6
Namoi 1.6	Murray 1.8	Sydney Metropolitan 1.8	

5. Options for monitoring

Almost half of all global extinctions of mammals recorded in the last 200 years were Australian species (Johnson 2006). The analyses presented in Section 2 suggest that this profound loss of mammalian fauna is reflected in NSW, where 19 per cent of terrestrial mammal species are presumed extinct. Despite these losses and significant losses of other vertebrate taxa, few resources have been invested in monitoring the sustainability of native vertebrates in NSW. Much of the data used in this report comes from the Atlas of Australian Birds, a database of surveys undertaken by volunteers and maintained by Birds Australia. While it is an extremely useful resource, long-term trends inferred from unplanned surveys may be subject to sampling artifacts. More importantly, almost no information is available for other taxonomic classes including mammals.

Under the criteria established in Section 3 (see also Appendix 2), there are three main variables used to assess the sustainability of a species:

- Total population size
- Total area of distribution
- Trend in population size or area of distribution over time.

Ideally, each of these variables would be monitored so that species could be assessed regularly against each of the criteria. For many species however, it may be neither feasible nor necessary to monitor each variable directly. Thus while various methods exist for estimating population size in vertebrates (Krebs 1989) they may be unreliable for all but the most conspicuous species (eg direct counts of large species in open habitats) or they may be prohibitively expensive to apply at large scales (eg mark-recapture). Estimates of total population size (specifically the number of mature individuals) are important for assessing species under Criteria C and D, but precise estimates are warranted for rare species only. Hence, there may be limited value in attempting to monitor total population size for most species.

For many species of mammals, reptiles and amphibians, the most productive approach may be to monitor occupancy (proportion of patches or sites occupied; Mackenzie et al. 2006) to provide a direct estimate of trend in distribution and to estimate other variables as required from the best available data. Monitoring occupancy should provide a robust measure of trend in distribution if sampling of species distributions is sufficient (ie enough sampling points to measure change with the desired resolution) and unbiased (ie a representative sample) and if the methods used to detect species are cost-effective (ie yield a high probability of detection for limited cost). Such data would allow species to be assessed rigorously under Criterion A. Occupancy data could then be combined with all other recent species records to estimate total area of distribution for the purposes of Criterion B. Monitoring occupancy would not provide sufficient data to allow assessment under Criteria C or D; however, these criteria are most relevant to rare species (as above).

It is unfeasible to monitor sustainability for all species of native vertebrate. However, given the scale of past losses and the paucity of current information, options for monitoring are discussed below.

5.1 Establish no new programs

The simplest option is to establish no new programs designed specifically to monitor the sustainability of native fauna at a state or regional scale but to review available data periodically. It is unlikely that data availability will improve however, as monitoring for other purposes rarely provides adequate spatial or temporal sampling of species distributions. Moreover, the future of many of the data sources used in this report is uncertain. Long-term funding for aerial waterbird surveys and threatened species programs is not secure, while the availability of data from the Atlas of Australian Birds in the future is unknown. As a minimum, securing existing data sources would allow the current analyses to be repeated in the future for comparison.

5.2 Monitor selected species

Monitoring could be established for individual species of native fauna where cost-effective detection techniques are available and potential distributions are relatively well known and accessible. While this could not be afforded for a large number of species, a small number of targeted programs could be established to improve representation across taxonomic classes and other criteria (eg geographic coverage, primary threat, ecosystem function). For example, species could be selected by considering the major threatening processes acting in different parts of the state. Targeted monitoring may be the only option for taxa with highly-specific habitat requirements, including many threatened species.

A targeted monitoring program was trialled for the long-nosed potoroo (*Potorous tridactylus*) in 2009 (Appendix 5). This species was selected as it is a medium-sized ground-dwelling mammal, and hence from the group of vertebrates that have experienced the greatest declines historically (see Section 2.3), but for which there are almost no data on sustainability. It is or was relatively widespread throughout eastern NSW and its primary threats (fox predation and habitat loss from clearing and altered fire regimes) are common to a broad range of taxa. Moreover, its potential distribution can be estimated from records and modelled habitat. Finally, the declining cost of high-resolution motion-triggered cameras means that a cost-effective method for obtaining occupancy data for a large sample of sites across its distribution may be available.

For the purposes of the trial, 100 one km^2 sites were selected throughout eastern NSW based on recent records and predicted habitat (Appendix 5). Sites were dispersed across the potential distribution by selecting a maximum of one site within each cell of a 20 km x 20 km grid covering NSW (the same grid as was used for calculating area of occupancy for NSW vertebrates in Section 2.1). Sites were censused using four cameras for two weeks. Of data available to June 2009, potoroos were detected at 13 of 49 sites (27 per cent). Based on presence/absence data for each day, the probability of detecting potoroos at sites where they were present using this technique was estimated to be greater than 99 per cent. A large number of other fauna species were also detected.

The trial showed that cameras could be used to detect potoroos cost-effectively at a large sample of sites across their distribution. Thus monitoring could be established to estimate long-term trends in occupancy and hence sustainability (Criteria A and B are likely to be the most relevant for this fairly widespread species). However, the power to detect trends will depend on a range of factors, most notably the number of sample sites, the duration of monitoring and between-year variance in site occupancy (see Section 6.1 for further discussion). Moreover, sampling of potoroo distribution in the trial was likely biased because access to sites and the likelihood of finding potoroos were considered in site selection.

A program targeting potoroos would also provide data on occupancy for a wide variety of other species, although any inferences regarding trends would be limited to potoroo habitat.

5.3 Establish non-targeted monitoring across species and areas

A more general approach to monitoring the sustainability of native fauna would be to sample the whole or large areas of NSW using a range of standardised techniques that might detect, or measure the abundance of, a wide variety of species. Sampling would not target the distribution or habitat of any particular species. Rather it would be established in a way that might allow trends in many species to be measured. Sampling could be systematic (eg on a grid), random or stratified by one or more variables that might reflect variation in the composition of fauna communities. Given sufficient sampling points, this approach has the potential to yield data for many species across a wide array of environments.

A stratified approach to monitoring mammals, reptiles and amphibians was trialled in the Western NRM region in 2009 based on landforms and IBRA regions (Appendix 6). IBRA regions (interim biogeographic regionalisation of Australia; Thackway & Cresswell 1995; DEWHA 2009) were developed for the purpose of planning for conservation reserves. They partition Australia based on predicted flora and fauna assemblages, geomorphology, climate and other attributes. At a finer scale, areas of similar topography, soil and vegetation in north-west NSW have been mapped into nine landforms (Walker 1991). The combination of landform and IBRA region was used to partition the Western region into 58 strata. Given the large number of strata, the intent was to establish monitoring on a subset of strata only. If the stratification reflected patterns in the distribution of different fauna assemblages, then monitoring a subset of strata may be an efficient way to sample the distributions of species associated with those strata. The number of strata targeted could be expanded over time as resources permit.

For the purposes of the trial, 16 sites were established within each of seven of the larger strata only (Appendix 6). For logistical reasons, sites were established only on conservation reserves and were spatially clumped within the strata (sites were typically 1 km apart). Small ground-dwelling species were censused at each site using a line of six pitfall and four funnel traps opened for four consecutive days in autumn. Timed nocturnal and diurnal searches were also undertaken at these sites. Incidental sightings were also recorded. Microbats were censused at one in every four sites for one night only using Anabat. Harp trapping was undertaken to collect reference calls of microbats as required. As with the trial program targeting long-nosed potoroo, the intent was to assess occupancy at many sites rather than measure abundance precisely at a few sites on the assumption that occupancy would fluctuate less and hence provide a more powerful measure of trend. This is particularly relevant in arid areas, where the abundance of many species may vary significantly in response to rainfall (Dickman et al. 1999a, 1999b).

Ten species of amphibians, 13 species of ground-dwelling mammals and 51 species of reptiles were detected across 112 sites. Of these, 15 species were detected at 11 (10 per cent) or more sites. Thirty-eight species were detected on more than one stratum. While trapping detected most of the species recorded at each site, time searches and incidental observations detected some species at sites where they had not been trapped. Census data for microbats are not yet analysed.

As with the trial program targeting potoroo, occupancy could be used to measure long-term trends in species distributions. This would require a significant number of additional sites to increase both the representativeness of sampling and the power to detect trends. The clustering of sites could be included as a nested factor in any analysis of trends.

However, sampling of each stratum (and any trends in fauna measured) is likely to remain biased irrespective of the number of additional sites established. Approximately 96 per cent of the Western region is privately managed, and many land managers may not support a monitoring program. Any declines in species distributions may be underestimated if sampling is biased towards conservation reserves and other lands subject to public investment in NRM (c.f. the sampling for potoroos). Similarly, sampling on public lands may be restricted by the availability of roads, risk to cultural heritage sites and other considerations.

Furthermore, the methods used in the trial were not cost-effective for detecting many species. While estimation of detection probabilities for each species has not been completed, trapping often failed to detect species that were otherwise observed at a site (Appendix 6, Table 2). Monitoring site occupancy when detection probabilities are low is unlikely to provide reliable estimates of trend (Mackenzie et al. 2006). The data also provide little support for persisting with the current stratification as more than half of all species observed were detected on more than one stratum. Thus focusing efforts on particular strata may not be an efficient way to sample the distributions of groups of species.

5.4 Establish systematic monitoring on a grid

Systematic sampling across a region or the state is an appealing alternative as it is likely to provide unbiased estimates of trends and no a-priori assumptions are necessary about the distribution of taxa. Systematic sampling of fauna, flora and other biophysical variables on a grid has been established in other parts of the world including Alberta (www.abmi.ca/abmi/home/home.jsp), Switzerland (www.biodiversitymonitoring.ch/english/aktuell/portal.php), and Sweden (http://nils.slu.se/). Collecting species occupancy and biophysical data from the same sites may allow important habitat attributes to be identified and the reliability of habitat-based indicators of biodiversity to be tested (eg remotely-sensed measures of vegetation extent and connectivity; Lindenmayer et al. 2000).

Forests NSW is trialling systematic sampling of biota and other environmental variables across a broad area of north-east NSW (Binns & Kavanagh pers. comm.). The trial is based on a 5 km x 5 km grid, with the primary sampling unit being a 1 km radius circle centred on the grid point. Various groups of taxa are sampled across the whole sampling unit or in subplots depending on the taxa. Target taxa include arboreal mammals, medium-sized ground-dwelling mammals, nocturnal birds, diurnal birds, microbats and vascular plants. Habitat attributes including tree hollows, logs and vegetation structure are also assessed. The objective of the trial is to assess whether this may be a cost-effective method for monitoring fauna across state forests. In the long-term, it is proposed that about one quarter of sample units be assessed each year, so that all units are assessed on a five-year cycle, with a selected subset of units assessed more frequently.

There are two main challenges to applying this approach to the whole of NSW. First, there are 32,186 points in the extrapolated state-wide grid. While the census techniques are designed to be rapid (eg no trapping), regular monitoring of this many points would require substantial resources even if done on a rotational basis. The problem could be reduced to some extent by using a larger grid spacing (ie fewer points) and estimating trends in occupancy from a smaller and perhaps less representative sample of species distributions.

As with the options discussed previously however, sampling will likely be biased irrespective of the grid spacing because of limitations on access to sampling points. Approximately 84 per cent of points on the state-wide 5 km grid lie on privately-managed lands. Access to many if not most of these points may not be supported by the land manager or may be otherwise inconsistent with the land use (eg industrial, commercial or residential areas). A further 8.4 per cent lie on national parks and nature reserves. Most reserves have considerably less road access than state forests, especially in wilderness areas. For example, of the 411 points that fall within the Greater Blue Mountains World Heritage Area, only 37 (nine per cent) lie within 200 m of roads, tracks or trials (Figure 10). Sampling accessible grid points only may result in large geographical areas not being monitored.

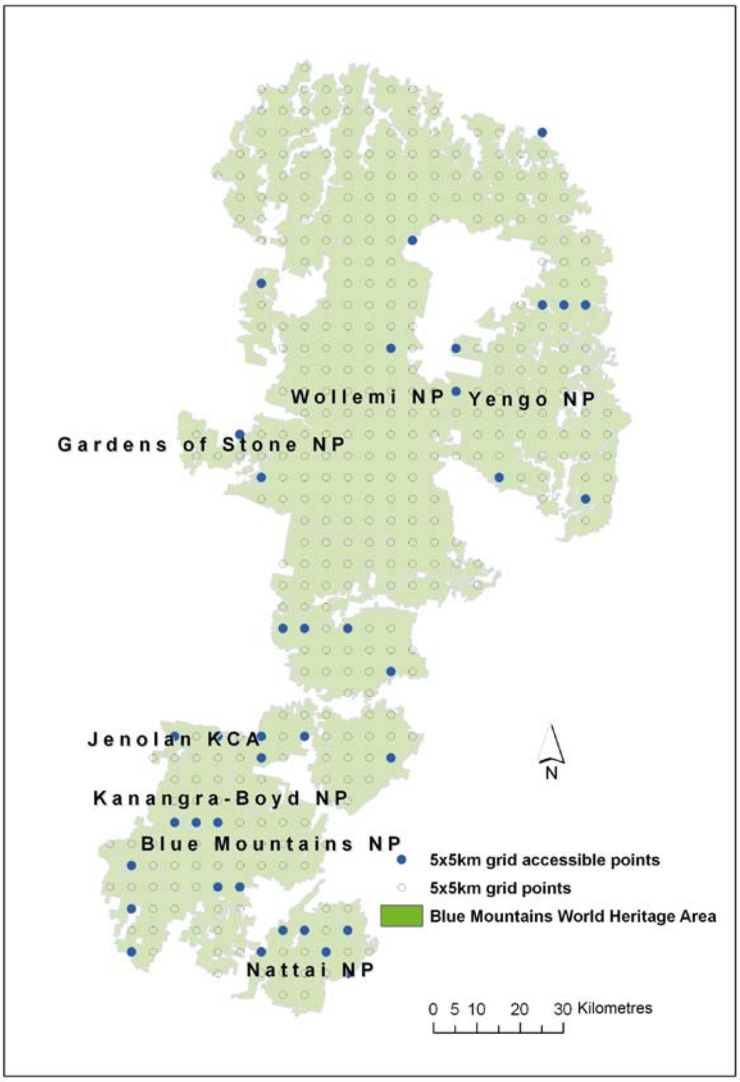


Figure 10: A 5 km grid overlaid on the Greater Blue Mountains World Heritage Area

Note: Only 37 of 411 sampling points (nine per cent) lie within 200 m of a road, track or trail.

5.5 Establish passive monitoring of species inventories

One alternative to monitoring trends in distribution for many individual species is to measure changes in species richness. Such a metric might be calculated from Atlas data for all terrestrial vertebrates using a fine-scale partitioning of NSW. This is appealing as a coarse but comprehensive metric of fauna sustainability could be established based on the long-term persistence of all native terrestrial vertebrate species measured at a fine scale across the state. The challenge is that species inventories derived from records – as opposed to active monitoring – may include many false absences (insufficient survey) and false presences (spatially or taxonomically inaccurate records).

To trial this approach, species inventories were derived for a 40 km x 40 km grid partitioning of NSW (as per Section 2.1) from the Atlas of NSW Wildlife and the Atlas of Australian Birds. Lists of species observed over all time and since 1 January 1996 (ie the last 12 years approximately) were drafted for each cell. Twelve years was chosen as a time period that might be sufficient for most species present within a cell to be detected, notwithstanding variation in survey effort between cells. Species lists were subject to expert review to identify doubtful species (false presences) and to assess their likely adequacy (false absences).

Mean species richness estimated from records over all time for 567 40 km x 40 km grid cells was 8.9, 160.3, 19.8, 23.1 for amphibians, birds, mammals and reptiles respectively (Appendix 7). Mean species richness estimated from records since 1 January 1996 was 6.8, 129.0, 16.1 and 15.4 respectively. These estimates exclude 3094 (mean 5.5 per cell) false presences identified by expert review. However, only 204 (36 per cent), 311 (55 per cent), 206 (36 per cent) and 222 (39 per cent) cell inventories were assessed as adequate in that they contained at least 75 per cent of species expected within that cell. This suggests that Atlas derived inventories cannot be used to monitor fauna without significant increases in survey and reporting across the state. Nevertheless, publishing inventories for each cell would provide local information on the diversity of native terrestrial vertebrates, it may motivate reporting of observations to improve or maintain current inventories at a relatively fine scale, and it may help prioritise future survey.

5.6 Monitor surrogates for fauna based on vegetation

Given the scale of the task, it may be appealing to monitor remotely-sensed surrogates for native fauna based on the extent and connectivity of native vegetation. Native vegetation is an essential component of the habitat of many species and hence monitoring vegetation may indicate trends in the availability of habitat. Such an approach is flawed however, as it assumes implicitly that habitat loss is the primary threat to the sustainability of native fauna. While it is clearly important, threats to native fauna are many and diverse (Coutts-Smith et al. 2007). Most fauna extinctions have occurred in western NSW, where the extent and connectivity of native vegetation remain high (Dillon et al. 2011). Predation by cats and foxes is likely to have been the primary cause of most of these extinctions (Dickman et al. 1993). Moreover, current trends in vegetation extent appear to be relatively stable (Dillon et al. 2011), while fauna continue to decline (Section 3; see also Woinarski et al. 2010). At a finer scale, remotely-sensed surrogates for occupancy of fauna species have often failed field validation (eg Lindenmayer et al. 2002). Thus we conclude that native vegetation may be necessary but not sufficient for indicating the persistence of fauna.

6. A proposal for a new fauna monitoring program in NSW

We propose that a new broad-scale fauna monitoring program be established to measure long-term trends in the distributions of native terrestrial vertebrate species in NSW. In particular, we propose that species occupancy be monitored at sample sites distributed across the state using a variety of detection techniques. As discussed in Section 5, this should provide a robust basis for assessing the sustainabilities of a wide range of native terrestrial vertebrate species. The task is to identify techniques that are cost-effective for detecting a range of taxa and an efficient sampling design that might provide estimates of trend with sufficient precision and accuracy to detect significant change. The program should be supplemented by targeted monitoring of a small selection of threatened species (see Section 6.3).

6.1 Motion-triggered cameras in eastern NSW

We propose that the program focus initially on the use of motion-triggered cameras to detect medium-sized ground-dwelling mammals and other vertebrate fauna at sample sites distributed across eastern NSW on accessible areas of conservation reserve. Medium-sized ground-dwelling mammals are a priority due to the severity of past losses of these species in NSW (Section 2.3), the lack of current data on their sustainability (Section 3.3) and the cost-effectiveness of motion-triggered cameras for detecting them (Appendix 5; Claridge et al. 2010). While it may be ideal to establish a camera program state-wide, most medium-sized mammals of western NSW are presumed extinct. While cameras are also likely to detect other medium to large vertebrate species that can be attracted readily to a point via a bait or lure, more work is needed to examine the cost-effectiveness of cameras for detecting western faunas.

As discussed in Section 5, sampling only accessible areas of conservation reserve may bias estimates of trend for many species. Thus we propose that options to expand the program to other tenures (especially other public lands) be investigated in the future. While sampling is likely to remain biased to some extent by accessibility, this will allow the effects of tenure on estimates of trend to be explored. Nevertheless, sampling on conservation reserves may be more sensitive to broad-scale declines in occupancy because reserves are likely to contain higher quality habitat for many species, and declines may be detected more readily where initial occupancy is higher (Rhodes et al. 2006). Monitoring conservation reserves will also provide a measure of the health of biodiversity on park, which may be important for guiding park management. It may also be possible to assess the effects of roads on estimates of trend to some degree depending on how sample sites are sub-sampled (see discussion below).

To define a boundary for the initial program, we overlaid the current extents of occurrence (derived in Section 2.1) of five widespread medium to large mammal species and one species of ground-dwelling bird in ArcGIS (Figure 11). A boundary for the proposal and a potential extension were drawn so as to enclose the majority of the overlaid distributions. While these six species are not the sole targets of monitoring, they create an envelope which might provide adequate coverage of the distributions of a suite of similar species. At a fine scale, the boundaries were aligned with the administrative areas of the NSW National Parks and Wildlife Service to assist in operational planning.

To develop a sampling regime, the area defined in Figure 11 was overlaid with a 1 x 1 km grid as used in Section 2.1. A total of 255,102 1 km grid cells were thus identified. The set of all accessible cells on national parks and nature reserves within this area was identified by overlaying a map of national parks estate and a map of roads and trails on the grid (ie accessible cells were approximated as those with a road or track passing through). A total of 33,956 accessible cells on park were thus identified within the proposed extent of the program.

The sample size required to detect a significant trend will depend not only on what is defined as significant, but also on the survey design, duration of monitoring and the Type 1 (α) and Type 2 (β) error rates (Legg & Nagy 2006). Here we suggest that the ability to detect species declining at a rate of 30 per cent per 10 years (equivalent to moderate risk or IUCN Vulnerable; Appendix 2 Criterion A2) is an appropriate objective. Nielsen et al. (2009) simulated declines of three per cent per annum (equivalent to approximately 26 per cent over 10 years) to examine the relationships between sample size, duration of monitoring and statistical power using data on detectability and prevalence for 252 species from the Alberta Monitoring Program (see Section 5.4). Accepting a Type 1 error of 0.1, they found that 90 per cent power was achieved for more than 50 per cent of species in each of three taxonomic groups after 10 years, when sampling 325 sites per year in a rotating panel design. When sampling 60 sites per year, 90 per cent power was achieved for the majority of species in each group after 20 years of monitoring.

These simulations provide a guide to the sample sizes that may be appropriate for this proposal (see below). We suggest that surveying 60 sites per year is inadequate if 20 years of monitoring is required to detect significant declines for most species. In contrast, surveying 325 sites per year may be appealing if it provides the ability to detect significant declines in the majority of species after 10 years. Nevertheless, increases in statistical power with sample size need to be traded against increases in the cost of implementation.

Mackenzie et al. (2006) compared the power of rotating panel designs with fixed sample sites to detect simulated declines in occupancy and concluded that power was a function of the number of sites sampled per season (time interval) and that there was little difference in power between fixed and rotating panel designs. However, power may be less in rotating panel designs if the sites surveyed in each season are confounded spatially because an additional model parameter (phase of rotation) would need to be estimated. Fixed sample sites may be easier for planning fieldwork as the same sites would be visited each season. Moreover, monitoring fixed sites would provide data on colonisation and local extinction probabilites each year and so evidence of any declines may be available sooner (Mackenzie et al. 2006). In contrast, rotating panel designs allow a greater number of sites to be surveyed overall, providing more opportunities to detect rare species or new threats. While the detection of rare species is likely to be too infrequent to estimate trend, such detections will improve information on species distribution and habitat preference.

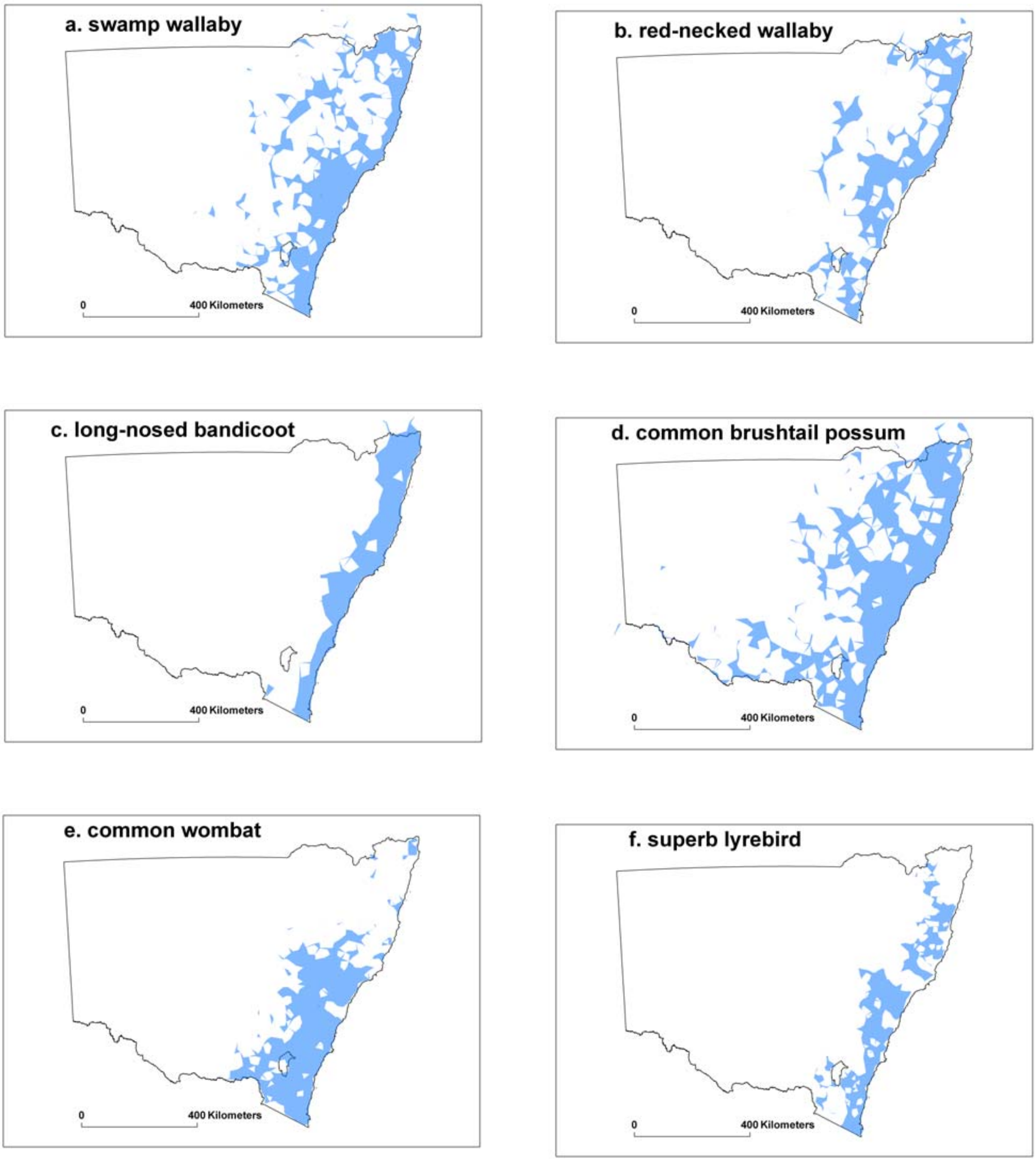
To explore these options, we randomly selected one accessible site (where available) from each cell of a 40 x 40 km grid and a 20 x 20 km grid overlaid on the program area (Figures 12 and 13 respectively). A total of 180 and 532 sites were thus identified. The objective of this approach was to ensure geographically-dispersed sampling of species distributions, as opposed to representative sampling of national parks and reserves. If fixed sample sites are preferred, then all 180 sites in Figure 12 could be surveyed over a 12-week period each year, with four teams of two staff (see Appendix 5). If a rotating panel is preferred, then the 532 sites in Figure 13 could be surveyed on a three-year rotation (about 177 sites per year) with the same resources. A third option may be to survey a randomly-selected subset of the 532 sites every year so as to provide some data on annual colonisation and extinction probabilities. Thus, if 64 of the 532 sites were monitored every year and the remainder monitored once every four years on rotational basis, then 181 sites would need to be monitored annually. Not all of the 40 x 40 km and 20 x 20 km cells have accessible 1 km^2 sites on park.

We believe that these options provide an appropriate starting point for the program pending further analysis. In particular, power analyses could be undertaken to assess these options using the detection probability and occupancy data from the trial, noting that the proposed study area is not identical to that used in the trial and the habitats to be sampled will be more variable. However, data on between-year fluctuations in occupancy will not be available until monitoring has been ongoing for several years.

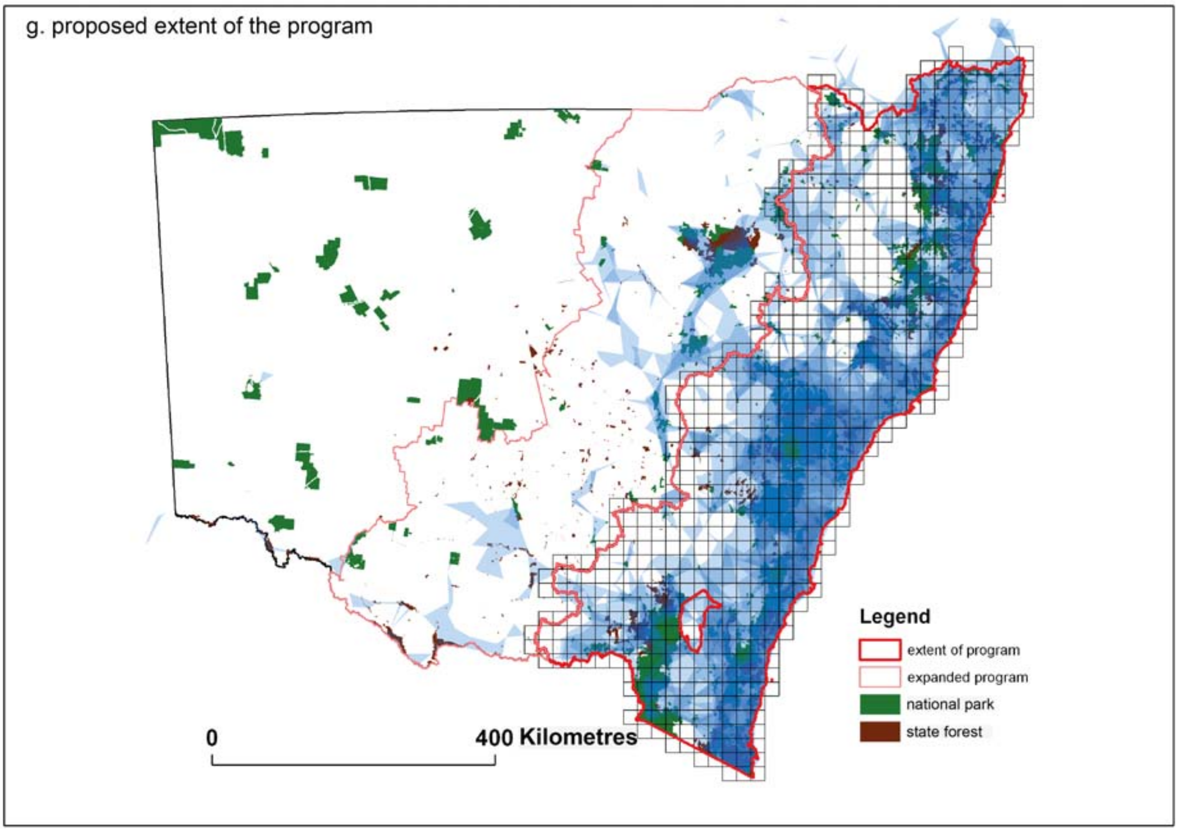
As with the trial for long-nosed potoroo (Appendix 5), we propose that occupancy of medium-sized mammals and other fauna be monitored using four motion-triggered cameras per 1 km^2 cell, set for two weeks per sampling period. Nominally, one camera should be located approximately in the centre of each quarter of the cell to provide an even coverage (hence giving species across the cell a chance to be detected). However, the precise locations may need to be varied depending upon access across the cell. Cameras should be set in the same locations each time a site is surveyed. Given that the distance from the camera locations to roads and tracks will vary, data from each camera location will provide some information on the effects of roads on trends in occupancy. A standardised attractant or bait should be used at each camera location.

Monitoring at one time of year only should eliminate variation in detection associated with season. We recommend late summer and early autumn as a trade-off between maximising the detection of reptiles (likely to be more active and thus more detectable in warmer months) and minimising the resource and logistical constraints associated with managing hazard reduction and wildfire on park (likely to be greatest from late winter to mid summer).

As with similar programs elsewhere (Section 5.4), a range of habitat variables should be measured in each cell concurrent with camera monitoring. For example, data on structure and type of vegetation, availability of habitat features and level of disturbance could be collected while setting or retrieving cameras. Data for some exotic species (eg cats, foxes, rabbits) could be obtained from the cameras but detection probabilities for carnivores are likely to be low. Field data could be combined with remotely-sensed information to explore their relationships with species occupancy (Lindenmayer et al. 2000).

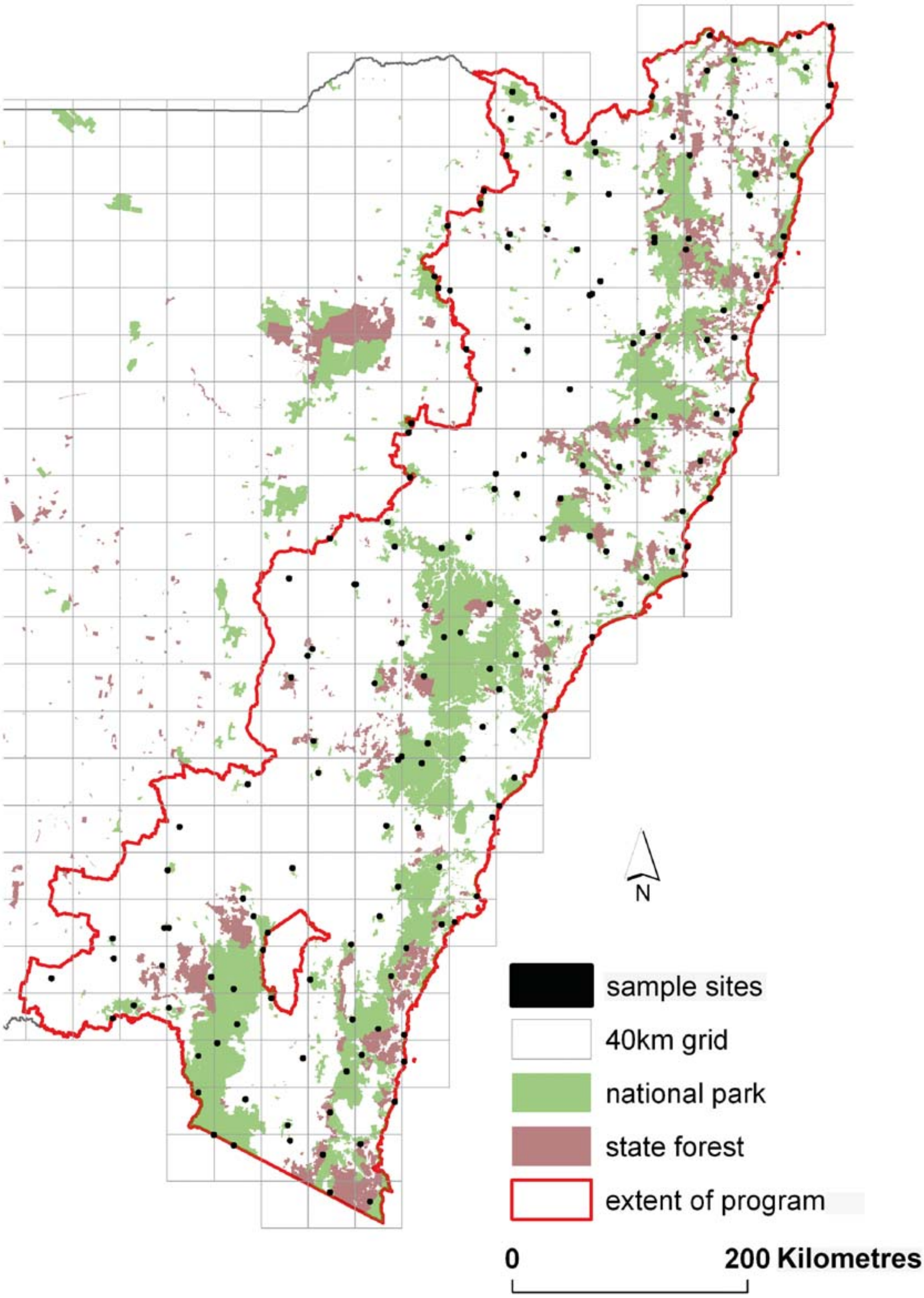


Figures a–f show the current extents of occurrence of 6 relatively-widespread species derived in Section 2. Figure g shows the proposed extent of the program and a potential expansion based on an overlay of these distributions. The boundaries align with administrative areas of the NSW NPWS.



Figures a–f show the current extents of occurrence of 6 relatively-widespread species derived in Section 2. Figure g shows the proposed extent of the program and a potential expansion based on an overlay of these distributions. The boundaries align with administrative areas of the NSW NPWS.

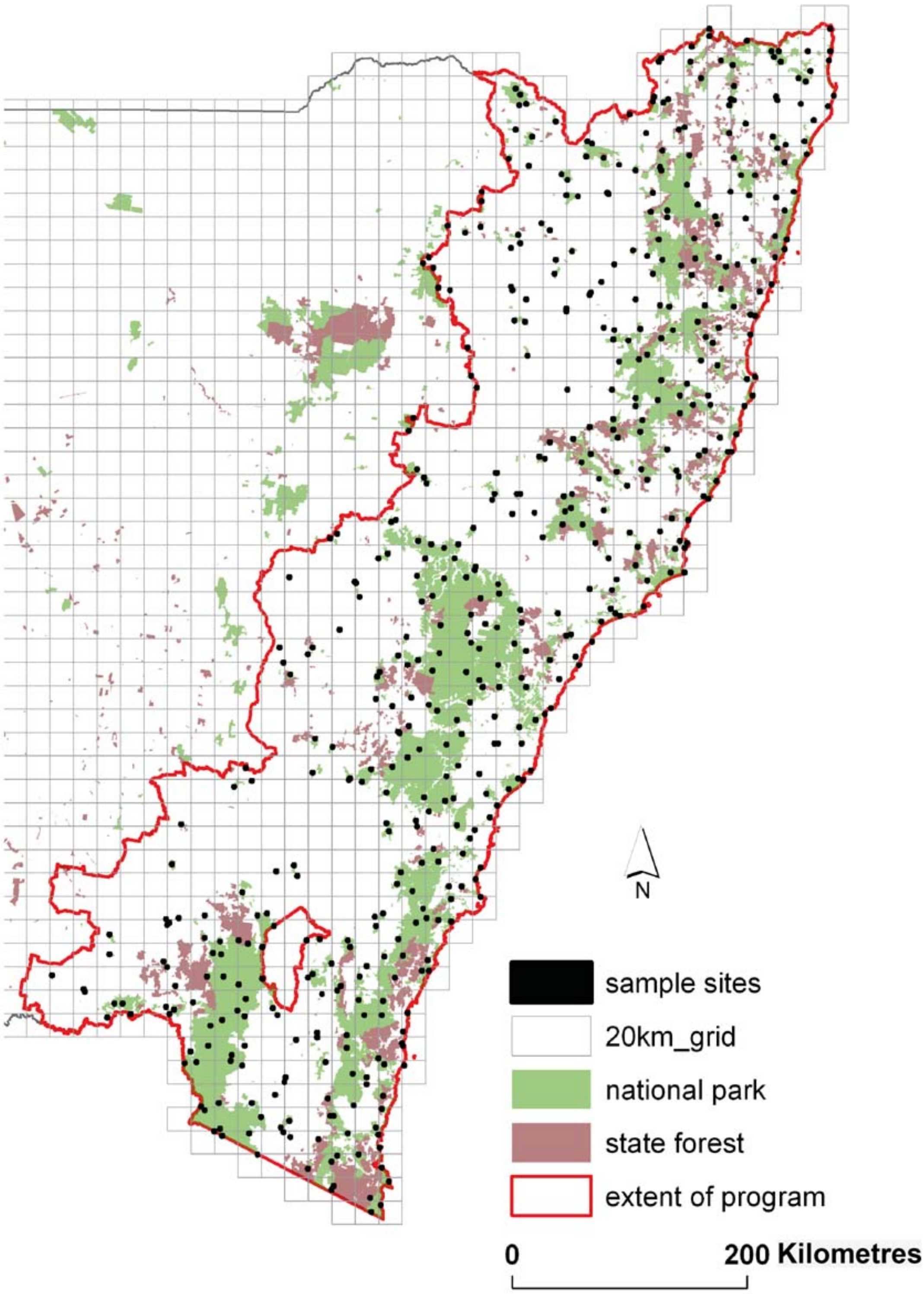
Figure 11: The extent of the proposed camera monitoring program



(N=33956)

Figure 12: 180 one km² sample sites selected at random from the set of all accessible sites on national park estate within the proposed extent of the initial program

Note: To ensure adequate dispersion, a maximum of one site was selected from within each cell of a 40 x 40 km grid covering the area.



(N=33956)

Figure 13: 532 one km² sample sites selected at random from the set of all accessible sites on national park estate within the proposed extent of the initial program

Note: To ensure adequate dispersion, a maximum of one site was selected from within each cell of a 20 x 20 km grid covering the area.

Implementation of the program should provide data on trends in occupancy for a suite of medium-sized mammals and other native fauna on national parks and nature reserves across eastern NSW. Notwithstanding the potential bias from sampling only on park, the data should provide a robust basis for assessing the sustainability of an important suite of species in NSW. It is likely that the program will generate reliable estimates of trend for only a subset of the many species that may be detected via cameras. However, detections of all species will improve knowledge of their current distributions, which will greatly assist park management. For example, infrequent detections of threatened species may influence pest and fire management on park.

Finally, the program could be integrated with other fauna monitoring, especially that designed to measure the effectiveness of management actions. Fox control is perhaps the primary management action on national parks and other public lands affecting medium-sized ground-dwelling mammals. Motion-triggered cameras have been trialled at several priority sites in the NSW Fox Threat Abatement Plan (NPWS 2001) to monitor the response of fauna to fox control. Integration of these programs should improve logistics and promote shared use of resources (cameras and people) and data.

6.2 Future expansion

The program could be expanded to other techniques (to detect other fauna), other tenures and other geographical areas in time. Other techniques (eg Anabat, bird surveys, amphibian and reptile searches) could be deployed in parallel with cameras to broaden the range of taxa detected, but we are cautious about the use of methods that are labour intensive or may result in significant differences in detection between observers. The program could be expanded to other tenures, including state forests, Crown land reserves and private lands. This may not only improve geographical coverage (ie allow sampling of those 40 x 40 km or 20 x 20 km cells that have no accessible cells on park) but it may also improve estimates of trends and elucidate any differences between tenures because tenure might be factored into the analyses. The potential to integrate with any future program developed for state forests should be explored (see Section 5.4).

More work is needed to identify cost-effective detection techniques before broad-scale monitoring of species occupancy should be initiated in western NSW. The trial described in Section 5.3 showed that pitfall and funnel traps could be used to detect a wide range of small mammals, reptiles and amphibians, but significant trapping effort may be required at each site to achieve adequate detection probabilities (eg many trap lines per sampling unit). The cost of doing this at many sites across western NSW may be prohibitive. Motion-triggered cameras could be trialled to examine their cost-effectiveness for detecting western faunas. In particular, it may be productive to trial cameras in the zone marked as a potential extension in Figure 11 to explore the current western extents of a range of medium-sized mammals.

6.3 Targeted monitoring of threatened fauna

The approach detailed above is likely to yield data for many more species of fauna for a given amount of resources than programs targeting selected species. However, the sampling design is likely to provide more reliable data for widespread species that occur across a range of habitats because these species will have a greater initial occupancy. A counterargument to this approach is that monitoring should target species with small population sizes or geographic ranges as these species are at the highest risk of extinction (as per IUCN criteria B–D). We suggest that monitoring widespread species is important for several reasons (Gaston & Fuller 2007, 2008). First, widespread species may also be at high risk of extinction if subject to widespread threatening processes now or in the future. Indeed, many Australian mammal species that have suffered regional or global extinction post-European settlement were widespread before the introduction of the house cat and the red fox. Second, widespread species form a major component of the biota of many environments and may be important for maintaining ecosystem functions. Third, broad-scale monitoring would sample more habitats and more geographical areas and hence the data will have broader interpretation and application for environment reporting and for the subsequent detection of new threats.

As a compromise, we propose that broad-scale monitoring of native fauna be supplemented by targeted monitoring of a small selection of threatened fauna. In particular, we advocate the establishment of a small number of targeted programs for species with small population sizes, limited geographic ranges and/or restricted habitat, although more work is needed to determine how these species should be selected. The first task is to identify those variables that are essential for assessing sustainability (extinction risk) for each species and to determine if they might be monitored cost-effectively (Section 5). Priorities for monitoring could then be aligned with priorities for the implementation of recovery programs (eg Joseph et al. 2009) so that monitoring aligns with investment. In addition, one could seek representation across taxonomic groups, geographic areas, primary threat and ecosystem function.

7. Recommendations

There is a clear need to develop new monitoring programs if the sustainability of native fauna is to be measured and reported objectively. Given limited resources, the following are recommended:

Monitoring

1. Secure future access to data from the Atlas of Australian Birds; explore alternative analysis techniques for these data.
2. Maintain current programs that measure the sustainability of species at a state scale (as used in this report), especially if these programs also measure the effects of management actions (eg aerial waterbird survey, some threatened species programs such as threatened shorebirds monitoring under the NSW Fox Threat Abatement Plan).
3. Establish a new program to monitor occupancy of medium-sized ground-dwelling mammals and other vertebrate fauna using motion-triggered cameras at sampling points on national parks and nature reserves across eastern NSW.
4. Expand to include other techniques (to detect other fauna), other geographical areas and other tenures as appropriate methods, resources and access are identified. As a priority, trial alternative methods that may be cost-effective for detecting western faunas, especially small mammals, reptiles and amphibians.
5. Identify a small set of threatened species for targeted monitoring aligned with prioritisation of the implementation of recovery programs. Representation across taxonomic groups, geographic areas, primary threat and ecosystem function may also be considered.

Evaluation

1. Employ the criteria detailed in Appendix 2 in future assessments of species sustainability, including the methods for addressing uncertainty illustrated in Figure 4.

Reporting

1. Publish data on the condition of species of native terrestrial vertebrates in NSW. This includes maps of past and current extents of occurrence (with caveats where confidence in the data is low), information on current monitoring, and assessments of sustainability where available.
2. Publish species inventories by grid-cell (Section 5.5). These maps may encourage new records to be submitted (both historic and recent) and aid in the review of existing records.

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Appendix 1: Historic declines and sustainability of native terrestrial vertebrates in NSW

Methods and categories for historic decline and sustainability assessments are given in Sections 2 and 3 respectively

Class	**Scientific name**	**Common name**	**Historic decline**	**Sustainability**
Amphibian	*Adelotus brevis*	Tusked Frog	moderate decline	data deficient
Amphibian	*Assa darlingtoni*	Pouched Frog	severe decline	data deficient
Amphibian	*Crinia deserticola*	Desert Froglet	data deficient	data deficient
Amphibian	*Crinia parinsignifera*	Eastern Sign-bearing Froglet	no significant decline	data deficient
Amphibian	*Crinia signifera*	Common Eastern Froglet	no significant decline	data deficient
Amphibian	*Crinia sloanei*	Sloane's Froglet	data deficient	data deficient
Amphibian	*Crinia tinnula*	Wallum Froglet	data deficient	data deficient
Amphibian	*Cyclorana alboguttata*	Striped Burrowing Frog	data deficient	data deficient
Amphibian	*Cyclorana brevipes*	Short-footed Frog	no significant decline	data deficient
Amphibian	*Cyclorana cultripes*	Knife-footed Frog	data deficient	data deficient
Amphibian	*Cyclorana novaehollandiae*	New Holland Frog	data deficient	data deficient
Amphibian	*Cyclorana platycephala*	Water-holding Frog	moderate decline	data deficient
Amphibian	*Cyclorana verrucosa*	Rough Frog	data deficient	data deficient
Amphibian	*Geocrinia victoriana*	Eastern Smooth Frog	data deficient	data deficient
Amphibian	*Heleioporus australiacus*	Giant Burrowing Frog	data deficient	data deficient
Amphibian	*Lechriodus fletcheri*	Fletcher's Frog	moderate decline	data deficient
Amphibian	*Limnodynastes dumerilii*	Eastern Banjo Frog	no significant decline	data deficient
Amphibian	*Limnodynastes fletcheri*	Long-thumbed Frog	no significant decline	data deficient
Amphibian	*Limnodynastes interioris*	Giant Banjo Frog	data deficient	data deficient
Amphibian	*Limnodynastes ornatus*	Ornate Burrowing Frog	no significant decline	data deficient
Amphibian	*Limnodynastes peronii*	Brown-striped Frog	no significant decline	data deficient
Amphibian	*Limnodynastes salmini*	Salmon Striped Frog	severe decline	data deficient
Amphibian	*Limnodynastes tasmaniensis*	Spotted Grass Frog	data deficient	data deficient

Class	Scientific name	Common name	Historic decline	Sustainability
Amphibian	*Limnodynastes terraereginae*	Northern Banjo Frog	data deficient	data deficient
Amphibian	*Litoria aurea*	Green and Golden Bell Frog	severe decline	data deficient
Amphibian	*Litoria barringtonensis*		data deficient	data deficient
Amphibian	*Litoria booroolongensis*	Booroolong Frog	severe decline	substantial risk
Amphibian	*Litoria brevipalmata*	Green-thighed Frog	data deficient	data deficient
Amphibian	*Litoria caerulea*	Green Tree Frog	data deficient	data deficient
Amphibian	*Litoria castanea*	Yellow-spotted Tree frog	severe decline	data deficient
Amphibian	*Litoria chloris*	Red-eyed Tree Frog	data deficient	data deficient
Amphibian	*Litoria citropa*	Blue Mountains Tree Frog	no significant decline	data deficient
Amphibian	*Litoria daviesae*	Davies' Tree Frog	data deficient	data deficient
Amphibian	*Litoria dentate*	Bleating Tree Frog	no significant decline	data deficient
Amphibian	*Litoria ewingii*	Brown Tree Frog	data deficient	data deficient
Amphibian	*Litoria fallax*	Eastern Dwarf Tree Frog	no significant decline	data deficient
Amphibian	*Litoria freycineti*	Freycinet's Frog	moderate decline	data deficient
Amphibian	*Litoria gracilenta*	Dainty Green Tree Frog	data deficient	data deficient
Amphibian	*Litoria jervisiensis*	Jervis Bay Tree Frog	data deficient	data deficient
Amphibian	*Litoria latopalmata*	Broad-palmed Frog	no significant decline	data deficient
Amphibian	*Litoria lesueuri*	Lesueur's Frog	data deficient	data deficient
Amphibian	*Litoria littlejohni*	Littlejohn's Tree Frog	data deficient	data deficient
Amphibian	*Litoria nasuta*	Rocket Frog	no significant decline	data deficient
Amphibian	*Litoria nudidigita*	Leaf Green River Tree Frog	data deficient	data deficient
Amphibian	*Litoria olongburensis*	Olongburra Frog	moderate decline	data deficient
Amphibian	*Litoria paraewingi*	Victorian Frog	data deficient	data deficient
Amphibian	*Litoria pearsoniana*	Pearson's Green Tree Frog	data deficient	data deficient
Amphibian	*Litoria peronii*	Peron's Tree Frog	data deficient	data deficient
Amphibian	*Litoria phyllochroa*	Leaf-green Tree Frog	data deficient	data deficient
Amphibian	*Litoria piperata*	Peppered Frog	severe decline	data deficient
Amphibian	*Litoria raniformis*	Southern Bell Frog	severe decline	data deficient

Class	Scientific name	Common name	Historic decline	Sustainability
Amphibian	*Litoria revelata*	Revealed Frog	data deficient	data deficient
Amphibian	*Litoria rubella*	Desert Tree Frog	no significant decline	data deficient
Amphibian	*Litoria spenceri*	Spotted Frog	data deficient	severe risk
Amphibian	*Litoria subglandulosa*	Glandular Frog	data deficient	data deficient
Amphibian	*Litoria tyleri*	Tyler's Tree Frog	no significant decline	data deficient
Amphibian	*Litoria verreauxii*	Verreaux's Frog	no significant decline	data deficient
Amphibian	*Litoria wilcoxii*		data deficient	data deficient
Amphibian	*Mixophyes balbus*	Stuttering Frog	data deficient	data deficient
Amphibian	*Mixophyes fasciolatus*	Great Barred Frog	no significant decline	data deficient
Amphibian	*Mixophyes fleayi*	Fleay's Barred Frog	data deficient	data deficient
Amphibian	*Mixophyes iteratus*	Giant Barred Frog	no significant decline	data deficient
Amphibian	*Neobatrachus centralis*	Trilling Frog	data deficient	data deficient
Amphibian	*Neobatrachus pictus*	Painted Burrowing Frog	data deficient	data deficient
Amphibian	*Neobatrachus sudelli*	Sudell's Frog	no significant decline	data deficient
Amphibian	*Notaden bennettii*	Crucifix Frog	moderate decline	data deficient
Amphibian	*Paracrinia haswelli*	Haswell's Froglet	data deficient	data deficient
Amphibian	*Philoria kundagungan*	Mountain Frog	data deficient	data deficient
Amphibian	*Philoria loveridgei*	Loveridge's Frog	data deficient	data deficient
Amphibian	*Philoria pughi*		data deficient	data deficient
Amphibian	*Philoria richmondensis*		data deficient	data deficient
Amphibian	*Philoria sphagnicolus*	Sphagnum Frog	data deficient	data deficient
Amphibian	*Pseudophryne australis*	Red-crowned Toadlet	data deficient	data deficient
Amphibian	*Pseudophryne bibronii*	Bibron's Toadlet	no significant decline	data deficient
Amphibian	*Pseudophryne coriacea*	Red-backed Toadlet	no significant decline	data deficient
Amphibian	*Pseudophryne corroboree*	Southern Corroboree Frog	severe decline	substantial risk
Amphibian	*Pseudophryne dendyi*	Southern Toadlet	no significant decline	data deficient
Amphibian	*Pseudophryne pengilleyi*	Northern Corroboree Frog	no significant decline	severe risk

Class	Scientific name	Common name	Historic decline	Sustainability
Amphibian	*Uperoleia capitulata*	Small-headed Toadlet	data deficient	data deficient
Amphibian	*Uperoleia fusca*	Dusky Toadlet	data deficient	data deficient
Amphibian	*Uperoleia laevigata*	Smooth Toadlet	data deficient	data deficient
Amphibian	*Uperoleia rugosa*	Wrinkled Toadlet	no significant decline	data deficient
Amphibian	*Uperoleia tyleri*	Tyler's Toadlet	data deficient	data deficient
Bird	*Acanthagenys rufogularis*	Spiny-cheeked Honeyeater	no significant decline	low risk
Bird	*Acanthiza apicalis*	Inland Thornbill	no significant decline	low risk
Bird	*Acanthiza chrysorrhoa*	Yellow-rumped Thornbill	data deficient	moderate risk
Bird	*Acanthiza lineata*	Striated Thornbill	no significant decline	data deficient
Bird	*Acanthiza nana*	Yellow Thornbill	data deficient	sustainable
Bird	*Acanthiza pusilla*	Brown Thornbill	data deficient	data deficient
Bird	*Acanthiza reguloides*	Buff-rumped Thornbill	no significant decline	substantial risk
Bird	*Acanthiza uropygialis*	Chestnut-rumped Thornbill	no significant decline	moderate risk
Bird	*Acanthorhynchus tenuirostris*	Eastern Spinebill	data deficient	sustainable
Bird	*Accipiter cirrocephalus*	Collared Sparrowhawk	no significant decline	moderate risk
Bird	*Accipiter fasciatus*	Brown Goshawk	data deficient	moderate risk
Bird	*Accipiter novaehollandiae*	Grey Goshawk	moderate decline	data deficient
Bird	*Acrocephalus australis*	Australian Reed-Warbler	no significant decline	data deficient
Bird	*Actitis hypoleucos*	Common Sandpiper	data deficient	data deficient
Bird	*Aegotheles cristatus*	Australian Owlet-nightjar	no significant decline	substantial risk
Bird	*Ailuroedus crassirostris*	Green Catbird	no significant decline	substantial risk
Bird	*Alcedo azurea*	Azure Kingfisher	no significant decline	moderate risk
Bird	*Alectura lathami*	Australian Brush-turkey	data deficient	data deficient
Bird	*Alisterus scapularis*	Australian King-Parrot	no significant decline	low risk
Bird	*Amaurornis olivaceus*	Bush-hen	moderate decline	data deficient

Class	Scientific name	Common name	Historic decline	Sustainability
Bird	*Amytornis barbatus barbatus*	Grey Grasswren	data deficient	data deficient
Bird	*Amytornis striatus*	Striated Grasswren	data deficient	data deficient
Bird	*Amytornis textilis modestus*	Thick-billed Grasswren (eastern subspecies)	data deficient	data deficient
Bird	*Anas castanea*	Chestnut Teal	no significant decline	sustainable
Bird	*Anas gracilis*	Grey Teal	data deficient	sustainable
Bird	*Anas rhynchotis*	Australasian Shoveler	data deficient	moderate risk
Bird	*Anas superciliosa*	Pacific Black Duck	no significant decline	sustainable
Bird	*Anhinga melanogaster*	Darter	no significant decline	data deficient
Bird	*Anous minutus*	Black Noddy	data deficient	data deficient
Bird	*Anous stolidus*	Common Noddy	data deficient	data deficient
Bird	*Anseranas semipalmata*	Magpie Goose	data deficient	data deficient
Bird	*Anthochaera carunculata*	Red Wattlebird	no significant decline	sustainable
Bird	*Anthochaera chrysoptera*	Little Wattlebird	no significant decline	data deficient
Bird	*Anthus australis*	Australian Pipit	data deficient	moderate risk
Bird	*Aphelocephala leucopsis*	Southern Whiteface	no significant decline	moderate risk
Bird	*Aphelocephala nigricincta*	Banded Whiteface	data deficient	data deficient
Bird	*Aplonis fusca hulliana*	Tasman Starling (Lord Howe Is. subsp.)	presumed extinct	presumed extinct
Bird	*Aprosmictus erythropterus*	Red-winged Parrot	no significant decline	moderate risk
Bird	*Apus pacificus*	Fork-tailed Swift	data deficient	data deficient
Bird	*Aquila audax*	Wedge-tailed Eagle	no significant decline	moderate risk
Bird	*Ardea alba*	Great Egret	no significant decline	substantial risk
Bird	*Ardea intermedia*	Intermediate Egret	no significant decline	data deficient
Bird	*Ardea pacifica*	White-necked Heron	data deficient	substantial risk
Bird	*Ardeotis australis*	Australian Bustard	moderate decline	data deficient
Bird	*Arenaria interpres*	Ruddy Turnstone	data deficient	data deficient

Class	Scientific name	Common name	Historic decline	Sustainability
Bird	*Artamus cinereus*	Black-faced Woodswallow	data deficient	substantial risk
Bird	*Artamus cyanopterus*	Dusky Woodswallow	data deficient	sustainable
Bird	*Artamus leucorynchus*	White-breasted Woodswallow	data deficient	data deficient
Bird	*Artamus minor*	Little Woodswallow	data deficient	substantial risk
Bird	*Artamus personatus*	Masked Woodswallow	no significant decline	moderate risk
Bird	*Artamus superciliosus*	White-browed Woodswallow	data deficient	data deficient
Bird	*Ashbyia lovensis*	Gibberbird	data deficient	data deficient
Bird	*Atrichornis rufescens*	Rufous Scrub-bird	moderate decline	data deficient
Bird	*Aviceda subcristata*	Pacific Baza	data deficient	moderate risk
Bird	*Aythya australis*	Hardhead	no significant decline	data deficient
Bird	*Barnardius zonarius*	Australian Ringneck	no significant decline	moderate risk
Bird	*Biziura lobata*	Musk Duck	moderate decline	moderate risk
Bird	*Botaurus poiciloptilus*	Australasian Bittern	no significant decline	data deficient
Bird	*Bubulcus ibis*	Cattle Egret	no significant decline	low risk
Bird	*Burhinus grallarius*	Bush Stone-curlew	moderate decline	data deficient
Bird	*Butorides striatus*	Striated Heron	no significant decline	data deficient
Bird	*Cacatua galerita*	Sulphur-crested Cockatoo	data deficient	low risk
Bird	*Cacatua leadbeateri*	Major Mitchell's Cockatoo	no significant decline	severe risk
Bird	*Cacatua sanguinea*	Little Corella	no significant decline	sustainable
Bird	*Cacatua tenuirostris*	Long-billed Corella	no significant decline	data deficient
Bird	*Cacomantis flabelliformis*	Fan-tailed Cuckoo	data deficient	moderate risk
Bird	*Cacomantis variolosus*	Brush Cuckoo	no significant decline	moderate risk
Bird	*Calamanthus campestris*	Rufous Fieldwren	data deficient	data deficient
Bird	*Calamanthus fuliginosus*	Striated Fieldwren	data deficient	data deficient

Class	Scientific name	Common name	Historic decline	Sustainability
Bird	*Calamanthus pyrrhopygius*	Chestnut-rumped Heathwren	data deficient	severe risk
Bird	*Calidris acuminata*	Sharp-tailed Sandpiper	data deficient	data deficient
Bird	*Calidris alba*	Sanderling	no significant decline	data deficient
Bird	*Calidris canutus*	Red Knot	data deficient	data deficient
Bird	*Calidris ferruginea*	Curlew Sandpiper	data deficient	data deficient
Bird	*Calidris melanotos*	Pectoral Sandpiper	data deficient	data deficient
Bird	*Calidris ruficollis*	Red-necked Stint	data deficient	data deficient
Bird	*Calidris tenuirostris*	Great Knot	moderate decline	data deficient
Bird	*Callocephalon fimbriatum*	Gang-gang Cockatoo	data deficient	substantial risk
Bird	*Calyptorhynchus banksii*	Red-tailed Black-Cockatoo	no significant decline	data deficient
Bird	*Calyptorhynchus funereus*	Yellow-tailed Black-Cockatoo	data deficient	substantial risk
Bird	*Calyptorhynchus lathami*	Glossy Black-Cockatoo	data deficient	substantial risk
Bird	*Centropus phasianinus*	Pheasant Coucal	data deficient	severe risk
Bird	*Certhionyx niger*	Black Honeyeater	no significant decline	substantial risk
Bird	*Certhionyx variegatus*	Pied Honeyeater	no significant decline	moderate risk
Bird	*Chalcites basalis*	Horsfield's Bronze-Cuckoo	no significant decline	moderate risk
Bird	*Chalcites lucidus*	Shining Bronze-Cuckoo	no significant decline	data deficient
Bird	*Chalcites minutillus*	Little Bronze-Cuckoo	data deficient	data deficient
Bird	*Chalcites osculans*	Black-eared Cuckoo	no significant decline	data deficient
Bird	*Chalcophaps indica*	Emerald Dove	moderate decline	severe risk
Bird	*Charadrius bicinctus*	Double-banded Plover	data deficient	data deficient
Bird	*Charadrius leschenaultii*	Greater Sand-plover	no significant decline	data deficient
Bird	*Charadrius mongolus*	Lesser Sand-plover	data deficient	data deficient
Bird	*Charadrius ruficapillus*	Red-capped Plover	data deficient	data deficient
Bird	*Charadrius veredus*	Oriental Plover	severe decline	data deficient
Bird	*Chenonetta jubata*	Australian Wood Duck	data deficient	low risk
Bird	*Cheramoeca leucosterna*	White-backed Swallow	data deficient	data deficient

Class	Scientific name	Common name	Historic decline	Sustainability
Bird	*Chlamydera maculata*	Spotted Bowerbird	data deficient	moderate risk
Bird	*Chlidonias hybridus*	Whiskered Tern	data deficient	data deficient
Bird	*Chlidonias leucopterus*	White-winged Black Tern	data deficient	severe risk
Bird	*Cincloramphus cruralis*	Brown Songlark	data deficient	moderate risk
Bird	*Cincloramphus mathewsi*	Rufous Songlark	no significant decline	moderate risk
Bird	*Cinclosoma castaneothorax*	Chestnut-breasted Quail-thrush	data deficient	data deficient
Bird	*Cinclosoma castanotus*	Chestnut Quail-thrush	data deficient	data deficient
Bird	*Cinclosoma cinnamomeum*	Cinnamon Quail-thrush	data deficient	data deficient
Bird	*Cinclosoma punctatum*	Spotted Quail-thrush	no significant decline	severe risk
Bird	*Circus approximans*	Swamp Harrier	data deficient	data deficient
Bird	*Circus assimilis*	Spotted Harrier	data deficient	data deficient
Bird	*Cisticola exilis*	Golden-headed Cisticola	no significant decline	moderate risk
Bird	*Cladorhynchus leucocephalus*	Banded Stilt	data deficient	substantial risk
Bird	*Climacteris affinis*	White-browed Treecreeper	data deficient	severe risk
Bird	*Climacteris erythrops*	Red-browed Treecreeper	data deficient	data deficient
Bird	*Climacteris picumnus*	Brown Treecreeper	severe decline	moderate risk
Bird	*Colluricincla harmonica*	Grey Shrike-thrush	moderate decline	sustainable
Bird	*Colluricincla megarhyncha*	Little Shrike-thrush	data deficient	data deficient
Bird	*Columba leucomela*	White-headed Pigeon	data deficient	severe risk
Bird	*Columba vitiensis godmanae*	White-throated Pigeon (Lord Howe Is. subsp.)	presumed extinct	presumed extinct
Bird	*Coracina lineata*	Barred Cuckoo-shrike	severe decline	data deficient
Bird	*Coracina maxima*	Ground Cuckoo-shrike	data deficient	substantial risk
Bird	*Coracina novaehollandiae*	Black-faced Cuckoo-shrike	data deficient	low risk
Bird	*Coracina papuensis*	White-bellied Cuckoo-shrike	no significant decline	moderate risk
Bird	*Coracina tenuirostris*	Cicadabird	no significant decline	moderate risk

Class	Scientific name	Common name	Historic decline	Sustainability
Bird	*Corcorax melanorhamphos*	White-winged Chough	no significant decline	sustainable
Bird	*Cormobates leucophaea*	White-throated Treecreeper	no significant decline	sustainable
Bird	*Corvus bennetti*	Little Crow	no significant decline	moderate risk
Bird	*Corvus coronoides*	Australian Raven	data deficient	moderate risk
Bird	*Corvus mellori*	Little Raven	no significant decline	low risk
Bird	*Corvus orru*	Torresian Crow	no significant decline	low risk
Bird	*Corvus tasmanicus*	Forest Raven	no significant decline	data deficient
Bird	*Coturnix chinensis*	King Quail	severe decline	data deficient
Bird	*Coturnix pectoralis*	Stubble Quail	no significant decline	substantial risk
Bird	*Coturnix ypsilophora*	Brown Quail	no significant decline	low risk
Bird	*Cracticus nigrogularis*	Pied Butcherbird	no significant decline	sustainable
Bird	*Cracticus torquatus*	Grey Butcherbird	data deficient	sustainable
Bird	*Cuculus pallidus*	Pallid Cuckoo	data deficient	substantial risk
Bird	*Cuculus saturatus*	Oriental Cuckoo	data deficient	data deficient
Bird	*Cyanoramphus novaezelandiae subflavescens*	Red-crowned Parakeet (Lord Howe Is. subsp.)	presumed extinct	presumed extinct
Bird	*Cyclopsitta diophthalma coxeni*	Double-eyed Fig-parrot	severe decline	data deficient
Bird	*Cygnus atratus*	Black Swan	no significant decline	data deficient
Bird	*Dacelo novaeguineae*	Laughing Kookaburra	data deficient	low risk
Bird	*Daphoenositta chrysoptera*	Varied Sittella	data deficient	substantial risk
Bird	*Dasyornis brachypterus*	Eastern Bristlebird	data deficient	data deficient
Bird	*Dendrocygna arcuata*	Wandering Whistling-Duck	data deficient	data deficient
Bird	*Dendrocygna eytoni*	Plumed Whistling-Duck	severe decline	sustainable
Bird	*Dicaeum hirundinaceum*	Mistletoebird	data deficient	low risk

Class	Scientific name	Common name	Historic decline	Sustainability
Bird	*Dicrurus bracteatus*	Spangled Drongo	no significant decline	moderate risk
Bird	*Dromaius novaehollandiae*	Emu	no significant decline	severe risk
Bird	*Drymodes brunneopygia*	Southern Scrub-robin	moderate decline	data deficient
Bird	*Egretta garzetta*	Little Egret	data deficient	low risk
Bird	*Egretta novaehollandiae*	White-faced Heron	data deficient	moderate risk
Bird	*Egretta sacra*	Eastern Reef Egret	data deficient	data deficient
Bird	*Elanus axillaris*	Black-shouldered Kite	no significant decline	low risk
Bird	*Elanus scriptus*	Letter-winged Kite	data deficient	data deficient
Bird	*Elseyornis melanops*	Black-fronted Dotterel	no significant decline	data deficient
Bird	*Emblema pictum*	Painted Finch	data deficient	data deficient
Bird	*Entomyzon cyanotis*	Blue-faced Honeyeater	no significant decline	moderate risk
Bird	*Eolophus roseicapillus*	Galah	data deficient	data deficient
Bird	*Eopsaltria australis*	Eastern Yellow Robin	data deficient	sustainable
Bird	*Ephippiorhynchus asiaticus*	Black-necked Stork	data deficient	data deficient
Bird	*Epthianura albifrons*	White-fronted Chat	data deficient	data deficient
Bird	*Epthianura aurifrons*	Orange Chat	data deficient	substantial risk
Bird	*Epthianura tricolor*	Crimson Chat	moderate decline	substantial risk
Bird	*Erythrogonys cinctus*	Red-kneed Dotterel	no significant decline	data deficient
Bird	*Erythrotriorchis radiatus*	Red Goshawk	severe decline	data deficient
Bird	*Esacus neglectus*	Beach Stone-curlew	data deficient	data deficient
Bird	*Eudynamys orientalis*	Pacific Koel	no significant decline	data deficient
Bird	*Eudyptula minor*	Little Penguin	data deficient	data deficient
Bird	*Eurostopodus argus*	Spotted Nightjar	data deficient	data deficient
Bird	*Eurostopodus mystacalis*	White-throated Nightjar	data deficient	data deficient
Bird	*Eurystomus orientalis*	Dollarbird	data deficient	moderate risk
Bird	*Falco berigora*	Brown Falcon	no significant decline	moderate risk
Bird	*Falco cenchroides*	Nankeen Kestrel	data deficient	moderate risk
Bird	*Falco hypoleucos*	Grey Falcon	moderate decline	data deficient

Class	Scientific name	Common name	Historic decline	Sustainability
Bird	*Falco longipennis*	Australian Hobby	no significant decline	moderate risk
Bird	*Falco peregrinus*	Peregrine Falcon	no significant decline	moderate risk
Bird	*Falco subniger*	Black Falcon	data deficient	substantial risk
Bird	*Falcunculus frontatus*	Eastern Shrike-tit	no significant decline	moderate risk
Bird	*Fregetta grallaria*	White-bellied Storm-Petrel	data deficient	data deficient
Bird	*Fulica atra*	Eurasian Coot	data deficient	data deficient
Bird	*Gallinago hardwickii*	Latham's Snipe	moderate decline	data deficient
Bird	*Gallinula tenebrosa*	Dusky Moorhen	no significant decline	sustainable
Bird	*Gallinula ventralis*	Black-tailed Native-hen	no significant decline	data deficient
Bird	*Gallirallus philippensis*	Buff-banded Rail	data deficient	data deficient
Bird	*Gallirallus sylvestris*	Lord Howe Woodhen	data deficient	data deficient
Bird	*Geopelia cuneata*	Diamond Dove	no significant decline	moderate risk
Bird	*Geopelia humeralis*	Bar-shouldered Dove	no significant decline	data deficient
Bird	*Geopelia placida*	Peaceful Dove	data deficient	data deficient
Bird	*Geophaps scripta*	Squatter Pigeon	data deficient	data deficient
Bird	*Gerygone fusca*	Western Gerygone	data deficient	low risk
Bird	*Gerygone igata insularis*	Grey Gerygone (Lord Howe Is. subsp.)	presumed extinct	presumed extinct
Bird	*Gerygone levigaster*	Mangrove Gerygone	no significant decline	severe risk
Bird	*Gerygone mouki*	Brown Gerygone	data deficient	data deficient
Bird	*Gerygone olivacea*	White-throated Gerygone	data deficient	sustainable
Bird	*Gliciphila melanops*	Tawny-crowned Honeyeater	data deficient	data deficient
Bird	*Glossopsitta concinna*	Musk Lorikeet	data deficient	data deficient
Bird	*Glossopsitta porphyrocephala*	Purple-crowned Lorikeet	data deficient	data deficient
Bird	*Glossopsitta pusilla*	Little Lorikeet	no significant decline	data deficient
Bird	*Grallina cyanoleuca*	Magpie-lark	data deficient	low risk

Class	Scientific name	Common name	Historic decline	Sustainability
Bird	*Grantiella picta*	Painted Honeyeater	no significant decline	data deficient
Bird	*Grus rubicunda*	Brolga	moderate decline	severe risk
Bird	*Gygis alba*	White Tern	data deficient	data deficient
Bird	*Gymnorhina tibicen*	Australian Magpie	no significant decline	low risk
Bird	*Haematopus fuliginosus*	Sooty Oystercatcher	no significant decline	data deficient
Bird	*Haematopus longirostris*	Pied Oystercatcher	moderate decline	substantial risk
Bird	*Haliaeetus leucogaster*	White-bellied Sea-Eagle	no significant decline	low risk
Bird	*Haliastur indus*	Brahminy Kite	data deficient	data deficient
Bird	*Haliastur sphenurus*	Whistling Kite	data deficient	low risk
Bird	*Hamirostra melanosternon*	Black-breasted Buzzard	data deficient	substantial risk
Bird	*Heteroscelus brevipes*	Grey-tailed Tattler	severe decline	substantial risk
Bird	*Heteroscelus incanus*	Wandering Tattler	severe decline	data deficient
Bird	*Hieraaetus morphnoides*	Little Eagle	data deficient	moderate risk
Bird	*Himantopus himantopus*	Black-winged Stilt	no significant decline	sustainable
Bird	*Hirundapus caudacutus*	White-throated Needletail	data deficient	data deficient
Bird	*Hirundo neoxena*	Welcome Swallow	data deficient	low risk
Bird	*Hylacola cauta*	Shy Heathwren	data deficient	data deficient
Bird	*Irediparra gallinacea*	Comb-crested Jacana	data deficient	data deficient
Bird	*Ixobrychus flavicollis*	Black Bittern	moderate decline	severe risk
Bird	*Ixobrychus minutus*	Little Bittern	data deficient	data deficient
Bird	*Lalage leucomela*	Varied Triller	data deficient	data deficient
Bird	*Lalage tricolor*	White-winged Triller	data deficient	data deficient
Bird	*Larus dominicanus*	Kelp Gull	data deficient	data deficient
Bird	*Larus novaehollandiae*	Silver Gull	data deficient	sustainable
Bird	*Larus pacificus*	Pacific Gull	data deficient	severe risk
Bird	*Lathamus discolor*	Swift Parrot	data deficient	low risk
Bird	*Leipoa ocellata*	Malleefowl	severe decline	data deficient
Bird	*Leucosarcia melanoleuca*	Wonga Pigeon	no significant decline	moderate risk
Bird	*Lewinia pectoralis*	Lewin's Rail	data deficient	data deficient

Class	Scientific name	Common name	Historic decline	Sustainability
Bird	*Lichenostomus chrysops*	Yellow-faced Honeyeater	data deficient	data deficient
Bird	*Lichenostomus cratitius*	Purple-gaped Honeyeater	data deficient	data deficient
Bird	*Lichenostomus fasciogularis*	Mangrove Honeyeater	data deficient	severe risk
Bird	*Lichenostomus fuscus*	Fuscous Honeyeater	no significant decline	data deficient
Bird	*Lichenostomus leucotis*	White-eared Honeyeater	no significant decline	sustainable
Bird	*Lichenostomus melanops*	Yellow-tufted Honeyeater	no significant decline	low risk
Bird	*Lichenostomus ornatus*	Yellow-plumed Honeyeater	no significant decline	data deficient
Bird	*Lichenostomus penicillatus*	White-plumed Honeyeater	data deficient	data deficient
Bird	*Lichenostomus plumulus*	Grey-fronted Honeyeater	moderate decline	substantial risk
Bird	*Lichenostomus virescens*	Singing Honeyeater	no significant decline	moderate risk
Bird	*Lichmera indistincta*	Brown Honeyeater	no significant decline	sustainable
Bird	*Limicola falcinellus*	Broad-billed Sandpiper	data deficient	data deficient
Bird	*Limosa lapponica*	Bar-tailed Godwit	data deficient	data deficient
Bird	*Limosa limosa*	Black-tailed Godwit	data deficient	data deficient
Bird	*Lonchura castaneothorax*	Chestnut-breasted Mannikin	data deficient	severe risk
Bird	*Lophoictinia isura*	Square-tailed Kite	moderate decline	data deficient
Bird	*Lopholaimus antarcticus*	Topknot Pigeon	no significant decline	substantial risk
Bird	*Macropygia amboinensis*	Brown Cuckoo-Dove	no significant decline	data deficient
Bird	*Malacorhynchus membranaceus*	Pink-eared Duck	no significant decline	substantial risk
Bird	*Malurus cyaneus*	Superb Fairy-wren	data deficient	low risk
Bird	*Malurus lamberti*	Variegated Fairy-wren	no significant decline	data deficient
Bird	*Malurus leucopterus*	White-winged Fairy-wren	data deficient	substantial risk
Bird	*Malurus melanocephalus*	Red-backed Fairy-wren	no significant decline	severe risk

Class	Scientific name	Common name	Historic decline	Sustainability
Bird	*Malurus splendens*	Splendid Fairy-wren	no significant decline	severe risk
Bird	*Manorina flavigula*	Yellow-throated Miner	no significant decline	moderate risk
Bird	*Manorina melanocephala*	Noisy Miner	data deficient	data deficient
Bird	*Manorina melanophrys*	Bell Miner	no significant decline	data deficient
Bird	*Manorina melanotis*	Black-eared Miner	data deficient	data deficient
Bird	*Megalurus gramineus*	Little Grassbird	no significant decline	substantial risk
Bird	*Megalurus timoriensis*	Tawny Grassbird	data deficient	data deficient
Bird	*Melanodryas cucullata*	Hooded Robin	moderate decline	substantial risk
Bird	*Meliphaga lewinii*	Lewin's Honeyeater	no significant decline	data deficient
Bird	*Melithreptus albogularis*	White-throated Honeyeater	no significant decline	substantial risk
Bird	*Melithreptus brevirostris*	Brown-headed Honeyeater	no significant decline	low risk
Bird	*Melithreptus lunatus*	White-naped Honeyeater	no significant decline	data deficient
Bird	*Melopsittacus undulatus*	Budgerigar	data deficient	substantial risk
Bird	*Menura alberti*	Albert's Lyrebird	severe decline	data deficient
Bird	*Menura novaehollandiae*	Superb Lyrebird	no significant decline	substantial risk
Bird	*Merops ornatus*	Rainbow Bee-eater	no significant decline	data deficient
Bird	*Microeca fascinans*	Jacky Winter	no significant decline	moderate risk
Bird	*Milvus migrans*	Black Kite	no significant decline	substantial risk
Bird	*Mirafra javanica*	Horsfield's Bushlark	data deficient	data deficient
Bird	*Monarcha leucotis*	White-eared Monarch	no significant decline	severe risk
Bird	*Monarcha melanopsis*	Black-faced Monarch	no significant decline	data deficient
Bird	*Monarcha trivirgatus*	Spectacled Monarch	data deficient	data deficient
Bird	*Motacilla flava*	Yellow Wagtail	data deficient	data deficient
Bird	*Myiagra cyanoleuca*	Satin Flycatcher	no significant decline	data deficient

Class	Scientific name	Common name	Historic decline	Sustainability
Bird	*Myiagra inquieta*	Restless Flycatcher	no significant decline	moderate risk
Bird	*Myiagra rubecula*	Leaden Flycatcher	no significant decline	data deficient
Bird	*Myzomela sanguinolenta*	Scarlet Honeyeater	no significant decline	data deficient
Bird	*Neochmia modesta*	Plum-headed Finch	moderate decline	data deficient
Bird	*Neochmia ruficauda*	Star Finch	presumed extinct	presumed extinct
Bird	*Neochmia temporalis*	Red-browed Finch	no significant decline	low risk
Bird	*Neophema chrysogaster*	Orange-bellied Parrot	data deficient	data deficient
Bird	*Neophema chrysostoma*	Blue-winged Parrot	no significant decline	data deficient
Bird	*Neophema elegans*	Elegant Parrot	data deficient	data deficient
Bird	*Neophema pulchella*	Turquoise Parrot	no significant decline	substantial risk
Bird	*Neophema splendida*	Scarlet-chested Parrot	data deficient	data deficient
Bird	*Neopsephotus bourkii*	Bourke's Parrot	data deficient	data deficient
Bird	*Nettapus coromandelianus*	Cotton Pygmy-Goose	data deficient	data deficient
Bird	*Ninox boobook*	Southern Boobook	no significant decline	severe risk
Bird	*Ninox connivens*	Barking Owl	data deficient	data deficient
Bird	*Ninox strenua*	Powerful Owl	data deficient	data deficient
Bird	*Northiella haematogaster*	Blue Bonnet	no significant decline	substantial risk
Bird	*Numenius madagascariensis*	Eastern Curlew	no significant decline	data deficient
Bird	*Numenius minutus*	Little Curlew	severe decline	data deficient
Bird	*Numenius phaeopus*	Whimbrel	no significant decline	data deficient
Bird	*Nycticorax caledonicus*	Nankeen Night Heron	no significant decline	moderate risk
Bird	*Nymphicus hollandicus*	Cockatiel	no significant decline	low risk
Bird	*Ocyphaps lophotes*	Crested Pigeon	data deficient	data deficient
Bird	*Oreoica gutturalis*	Crested Bellbird	no significant decline	substantial risk
Bird	*Origma solitaria*	Rockwarbler	data deficient	substantial risk

Class	Scientific name	Common name	Historic decline	Sustainability
Bird	*Oriolus sagittatus*	Olive-backed Oriole	no significant decline	data deficient
Bird	*Orthonyx temminckii*	Logrunner	no significant decline	severe risk
Bird	*Oxyura australis*	Blue-billed Duck	no significant decline	severe risk
Bird	*Pachycephala inornata*	Gilbert's Whistler	data deficient	substantial risk
Bird	*Pachycephala olivacea*	Olive Whistler	no significant decline	data deficient
Bird	*Pachycephala pectoralis*	Golden Whistler	no significant decline	data deficient
Bird	*Pachycephala rufiventris*	Rufous Whistler	moderate decline	sustainable
Bird	*Pachycephala rufogularis*	Red-lored Whistler	data deficient	data deficient
Bird	*Pandion haliaetus*	Osprey	data deficient	data deficient
Bird	*Pardalotus punctatus*	Spotted Pardalote	no significant decline	data deficient
Bird	*Pardalotus rubricatus*	Red-browed Pardalote	data deficient	data deficient
Bird	*Pardalotus striatus*	Striated Pardalote	data deficient	sustainable
Bird	*Pedionomus torquatus*	Plains-wanderer	severe decline	data deficient
Bird	*Pelagodroma marina*	White-faced Storm-Petrel	data deficient	data deficient
Bird	*Pelecanus conspicillatus*	Australian Pelican	data deficient	sustainable
Bird	*Peltohyas australis*	Inland Dotterel	data deficient	data deficient
Bird	*Petrochelidon ariel*	Fairy Martin	no significant decline	moderate risk
Bird	*Petrochelidon nigricans*	Tree Martin	no significant decline	sustainable
Bird	*Petroica boodang*	Scarlet Robin	data deficient	low risk
Bird	*Petroica goodenovii*	Red-capped Robin	no significant decline	moderate risk
Bird	*Petroica phoenicea*	Flame Robin	data deficient	moderate risk
Bird	*Petroica rodinogaster*	Pink Robin	data deficient	data deficient
Bird	*Petroica rosea*	Rose Robin	no significant decline	moderate risk
Bird	*Pezoporus occidentalis*	Night Parrot	presumed extinct	presumed extinct
Bird	*Pezoporus wallicus wallicus*	Eastern Ground Parrot	moderate decline	data deficient
Bird	*Phaethon rubricauda*	Red-tailed Tropicbird	data deficient	data deficient
Bird	*Phalacrocorax carbo*	Great Cormorant	data deficient	data deficient

Class	Scientific name	Common name	Historic decline	Sustainability
Bird	*Phalacrocorax fuscescens*	Black-faced Cormorant	data deficient	data deficient
Bird	*Phalacrocorax melanoleucos*	Little Pied Cormorant	data deficient	sustainable
Bird	*Phalacrocorax sulcirostris*	Little Black Cormorant	data deficient	sustainable
Bird	*Phalacrocorax varius*	Pied Cormorant	no significant decline	low risk
Bird	*Phaps chalcoptera*	Common Bronzewing	no significant decline	low risk
Bird	*Phaps elegans*	Brush Bronzewing	no significant decline	data deficient
Bird	*Phaps histrionica*	Flock Bronzewing	data deficient	data deficient
Bird	*Philemon citreogularis*	Little Friarbird	data deficient	sustainable
Bird	*Philemon corniculatus*	Noisy Friarbird	no significant decline	sustainable
Bird	*Phylidonyris albifrons*	White-fronted Honeyeater	no significant decline	data deficient
Bird	*Phylidonyris niger*	White-cheeked Honeyeater	no significant decline	data deficient
Bird	*Phylidonyris novaehollandiae*	New Holland Honeyeater	no significant decline	moderate risk
Bird	*Phylidonyris pyrrhoptera*	Crescent Honeyeater	no significant decline	moderate risk
Bird	*Pitta versicolor*	Noisy Pitta	no significant decline	severe risk
Bird	*Platalea flavipes*	Yellow-billed Spoonbill	no significant decline	substantial risk
Bird	*Platalea regia*	Royal Spoonbill	no significant decline	data deficient
Bird	*Platycercus adscitus adscitus*	Pale-headed Rosella	no significant decline	data deficient
Bird	*Platycercus adscitus eximius*	Eastern Rosella	no significant decline	sustainable
Bird	*Platycercus elegans*	Crimson Rosella	no significant decline	substantial risk
Bird	*Plectorhyncha lanceolata*	Striped Honeyeater	no significant decline	sustainable
Bird	*Plegadis falcinellus*	Glossy Ibis	data deficient	data deficient
Bird	*Pluvialis dominica*	Lesser Golden Plover	moderate decline	data deficient
Bird	*Pluvialis fulva*	Pacific Golden Plover	data deficient	data deficient

Class	Scientific name	Common name	Historic decline	Sustainability
Bird	*Pluvialis squatarola*	Grey Plover	data deficient	data deficient
Bird	*Podargus ocellatus*	Marbled Frogmouth	moderate decline	data deficient
Bird	*Podargus strigoides*	Tawny Frogmouth	no significant decline	moderate risk
Bird	*Podiceps cristatus*	Great Crested Grebe	data deficient	data deficient
Bird	*Poephila cincta cincta*	Black-throated Finch (southern subspecies)	severe decline	data deficient
Bird	*Poliocephalus poliocephalus*	Hoary-headed Grebe	no significant decline	moderate risk
Bird	*Polytelis anthopeplus monarchoides*	Regent Parrot (eastern subsp.)	no significant decline	data deficient
Bird	*Polytelis swainsonii*	Superb Parrot	data deficient	data deficient
Bird	*Pomatostomus halli*	Hall's Babbler	no significant decline	data deficient
Bird	*Pomatostomus ruficeps*	Chestnut-crowned Babbler	no significant decline	substantial risk
Bird	*Pomatostomus superciliosus*	White-browed Babbler	no significant decline	substantial risk
Bird	*Pomatostomus temporalis temporalis*	Grey-crowned Babbler (eastern subspecies)	no significant decline	sustainable
Bird	*Porphyrio albus*	White Gallinule	presumed extinct	presumed extinct
Bird	*Porphyrio porphyrio*	Purple Swamphen	no significant decline	data deficient
Bird	*Porzana fluminea*	Australian Spotted Crake	moderate decline	data deficient
Bird	*Porzana pusilla*	Baillon's Crake	moderate decline	data deficient
Bird	*Porzana tabuensis*	Spotless Crake	no significant decline	data deficient
Bird	*Procelsterna cerulea*	Grey Ternlet	data deficient	data deficient
Bird	*Psephotus haematonotus*	Red-rumped Parrot	no significant decline	data deficient
Bird	*Psephotus pulcherrimus*	Paradise Parrot	presumed extinct	presumed extinct
Bird	*Psephotus varius*	Mulga Parrot	data deficient	moderate risk
Bird	*Psophodes cristatus*	Chirruping Wedgebill	no significant decline	data deficient
Bird	*Psophodes olivaceus*	Eastern Whipbird	no significant decline	data deficient
Bird	*Pterodroma leucoptera leucoptera*	Gould's Petrel	severe decline	data deficient

Class	Scientific name	Common name	Historic decline	Sustainability
Bird	*Pterodroma neglecta neglecta*	Kermadec Petrel (west Pacific subspecies)	data deficient	data deficient
Bird	*Pterodroma nigripennis*	Black-winged Petrel	data deficient	data deficient
Bird	*Pterodroma solandri*	Providence Petrel	data deficient	data deficient
Bird	*Ptilinopus magnificus*	Wompoo Fruit-Dove	data deficient	substantial risk
Bird	*Ptilinopus regina*	Rose-crowned Fruit-Dove	data deficient	severe risk
Bird	*Ptilinopus superbus*	Superb Fruit-Dove	moderate decline	data deficient
Bird	*Ptilonorhynchus violaceus*	Satin Bowerbird	no significant decline	sustainable
Bird	*Ptiloris paradiseus*	Paradise Riflebird	no significant decline	data deficient
Bird	*Puffinus assimilis*	Little Shearwater	data deficient	data deficient
Bird	*Puffinus carneipes*	Flesh-footed Shearwater	data deficient	data deficient
Bird	*Puffinus griseus*	Sooty Shearwater	data deficient	data deficient
Bird	*Puffinus pacificus*	Wedge-tailed Shearwater	data deficient	data deficient
Bird	*Puffinus tenuirostris*	Short-tailed Shearwater	data deficient	data deficient
Bird	*Pycnoptilus floccosus*	Pilotbird	data deficient	substantial risk
Bird	*Pyrrholaemus brunneus*	Redthroat	moderate decline	data deficient
Bird	*Pyrrholaemus saggitatus*	Speckled Warbler	no significant decline	moderate risk
Bird	*Recurvirostra novaehollandiae*	Red-necked Avocet	data deficient	substantial risk
Bird	*Rhipidura albiscapa*	Grey Fantail	moderate decline	data deficient
Bird	*Rhipidura fuliginosa cervina*	Grey Fantail (Lord Howe Is. subsp.)	presumed extinct	presumed extinct
Bird	*Rhipidura leucophrys*	Willie Wagtail	no significant decline	sustainable
Bird	*Rhipidura rufifrons*	Rufous Fantail	no significant decline	data deficient
Bird	*Rostratula benghalensis australis*	Painted Snipe (Australian subspecies)	severe decline	data deficient
Bird	*Scythrops novaehollandiae*	Channel-billed Cuckoo	no significant decline	data deficient
Bird	*Sericornis citreogularis*	Yellow-throated Scrubwren	no significant decline	data deficient
Bird	*Sericornis frontalis*	White-browed Scrubwren	no significant decline	data deficient

Class	Scientific name	Common name	Historic decline	Sustainability
Bird	*Sericornis magnirostris*	Large-billed Scrubwren	no significant decline	data deficient
Bird	*Sericulus chrysocephalus*	Regent Bowerbird	no significant decline	data deficient
Bird	*Smicrornis brevirostris*	Weebill	no significant decline	data deficient
Bird	*Sphecotheres vieilloti*	Australasian Figbird	data deficient	low risk
Bird	*Stagonopleura bella*	Beautiful Firetail	no significant decline	severe risk
Bird	*Stagonopleura guttata*	Diamond Firetail	no significant decline	moderate risk
Bird	*Sterna albifrons*	Little Tern	severe decline	moderate risk
Bird	*Sterna bergii*	Crested Tern	no significant decline	data deficient
Bird	*Sterna caspia*	Caspian Tern	data deficient	data deficient
Bird	*Sterna fuscata*	Sooty Tern	data deficient	data deficient
Bird	*Sterna nereis*	Fairy Tern	data deficient	data deficient
Bird	*Sterna nilotica*	Gull-billed Tern	data deficient	data deficient
Bird	*Stictonetta naevosa*	Freckled Duck	moderate decline	data deficient
Bird	*Stiltia Isabella*	Australian Pratincole	data deficient	data deficient
Bird	*Stipiturus malachurus*	Southern Emu-wren	no significant decline	substantial risk
Bird	*Stipiturus mallee*	Mallee Emu-wren	data deficient	data deficient
Bird	*Strepera graculina*	Pied Currawong	no significant decline	low risk
Bird	*Strepera versicolor*	Grey Currawong	no significant decline	substantial risk
Bird	*Struthidea cinerea*	Apostlebird	no significant decline	moderate risk
Bird	*Sula dactylatra*	Masked Booby	data deficient	data deficient
Bird	*Tachybaptus novaehollandiae*	Australasian Grebe	no significant decline	sustainable
Bird	*Tadorna tadornoides*	Australian Shelduck	data deficient	data deficient
Bird	*Taeniopygia bichenovii*	Double-barred Finch	no significant decline	data deficient
Bird	*Taeniopygia guttata*	Zebra Finch	no significant decline	moderate risk
Bird	*Thinornis rubricollis*	Hooded Plover	data deficient	substantial risk

Class	Scientific name	Common name	Historic decline	Sustainability
Bird	*Threskiornis molucca*	Australian White Ibis	data deficient	low risk
Bird	*Threskiornis spinicollis*	Straw-necked Ibis	data deficient	low risk
Bird	*Todiramphus chloris*	Collared Kingfisher	data deficient	data deficient
Bird	*Todiramphus macleayii*	Forest Kingfisher	no significant decline	substantial risk
Bird	*Todiramphus pyrrhopygia*	Red-backed Kingfisher	data deficient	substantial risk
Bird	*Todiramphus sanctus*	Sacred Kingfisher	no significant decline	sustainable
Bird	*Tregellasia capito*	Pale-yellow Robin	moderate decline	data deficient
Bird	*Trichoglossus chlorolepidotus*	Scaly-breasted Lorikeet	no significant decline	low risk
Bird	*Trichoglossus haematodus*	Rainbow Lorikeet	no significant decline	data deficient
Bird	*Tringa glareola*	Wood Sandpiper	data deficient	data deficient
Bird	*Tringa nebularia*	Common Greenshank	data deficient	data deficient
Bird	*Tringa stagnatilis*	Marsh Sandpiper	moderate decline	data deficient
Bird	*Turdus poliocephalus vinitinctus*	Island Thrush (Lord Howe Is. subsp.)	presumed extinct	presumed extinct
Bird	*Turnix maculosa*	Red-backed Button-quail	severe decline	data deficient
Bird	*Turnix melanogaster*	Black-breasted Button-quail	severe decline	data deficient
Bird	*Turnix pyrrhothorax*	Red-chested Button-quail	data deficient	data deficient
Bird	*Turnix varia*	Painted Button-quail	data deficient	substantial risk
Bird	*Turnix velox*	Little Button-quail	data deficient	data deficient
Bird	*Tyto alba*	Barn Owl	no significant decline	data deficient
Bird	*Tyto capensis*	Grass Owl	severe decline	data deficient
Bird	*Tyto novaehollandiae*	Masked Owl	data deficient	data deficient
Bird	*Tyto tenebricosa*	Sooty Owl	data deficient	data deficient
Bird	*Vanellus miles*	Masked Lapwing	data deficient	sustainable
Bird	*Vanellus tricolor*	Banded Lapwing	data deficient	data deficient
Bird	*Xanthomyza phrygia*	Regent Honeyeater	data deficient	severe risk
Bird	*Xenus cinereus*	Terek Sandpiper	no significant decline	data deficient
Bird	*Zoothera heinei*	Russet-tailed Thrush	no significant decline	data deficient

Class	Scientific name	Common name	Historic decline	Sustainability
Bird	*Zoothera lunulata*	Bassian Thrush	data deficient	moderate risk
Bird	*Zosterops lateralis*	Silvereye	data deficient	sustainable
Bird	*Zosterops tenuirostris strenuous*	Robust White-eye	presumed extinct	presumed extinct
Mammal	*Acrobates pygmaeus*	Feathertail Glider	no significant decline	data deficient
Mammal	*Aepyprymnus rufescens*	Rufous Bettong	moderate decline	data deficient
Mammal	*Antechinomys laniger*	Kultarr	severe decline	data deficient
Mammal	*Antechinus agilis*	Agile Antechinus	data deficient	data deficient
Mammal	*Antechinus flavipes*	Yellow-footed Antechinus	no significant decline	data deficient
Mammal	*Antechinus stuartii*	Brown Antechinus	data deficient	data deficient
Mammal	*Antechinus subtropicus*	Subtropical Antechinus	data deficient	data deficient
Mammal	*Antechinus swainsonii*	Dusky Antechinus	data deficient	data deficient
Mammal	*Arctocephalus forsteri*	New Zealand Fur-seal	data deficient	data deficient
Mammal	*Bettongia gaimardi*	Tasmanian Bettong	presumed extinct	presumed extinct
Mammal	*Bettongia lesueur graii*	Burrowing Bettong	presumed extinct	presumed extinct
Mammal	*Bettongia penicillata penicillata*	Brush-tailed Bettong	presumed extinct	presumed extinct
Mammal	*Bettongia tropica*	Northern Bettong	presumed extinct	presumed extinct
Mammal	*Burramys parvus*	Mountain Pygmy-possum	data deficient	severe risk
Mammal	*Cercartetus concinnus*	Western Pygmy Possum	data deficient	data deficient
Mammal	*Cercartetus nanus*	Eastern Pygmy-possum	no significant decline	data deficient
Mammal	*Chaeropus ecaudatus*	Pig-footed Bandicoot	presumed extinct	presumed extinct
Mammal	*Chalinolobus dwyeri*	Large-eared Pied Bat	data deficient	data deficient
Mammal	*Chalinolobus gouldii*	Gould's Wattled Bat	data deficient	data deficient
Mammal	*Chalinolobus morio*	Chocolate Wattled Bat	data deficient	data deficient
Mammal	*Chalinolobus nigrogriseus*	Hoary Wattled Bat	data deficient	data deficient
Mammal	*Chalinolobus picatus*	Little Pied Bat	data deficient	data deficient
Mammal	*Conilurus albipes*	White-footed Tree-rat	presumed extinct	presumed extinct
Mammal	*Dasycercus cristicauda*	Mulgara	presumed extinct	presumed extinct
Mammal	*Dasyurus geoffroii*	Western Quoll	presumed extinct	presumed extinct
Mammal	*Dasyurus maculatus*	Spotted-tailed Quoll	data deficient	data deficient
Mammal	*Dasyurus viverrinus*	Eastern Quoll	severe decline	data deficient

Class	Scientific name	Common name	Historic decline	Sustainability
Mammal	*Falsistrellus tasmaniensis*	Eastern False Pipistrelle	data deficient	data deficient
Mammal	*Hydromys chrysogaster*	Water-rat	moderate decline	data deficient
Mammal	*Isoodon auratus auratus*	Golden Bandicoot (mainland)	presumed extinct	presumed extinct
Mammal	*Isoodon macrourus*	Northern Brown Bandicoot	no significant decline	data deficient
Mammal	*Isoodon obesulus obesulus*	Southern Brown Bandicoot (eastern)	severe decline	data deficient
Mammal	*Kerivoula papuensis*	Golden-tipped Bat	data deficient	data deficient
Mammal	*Lagorchestes leporides*	Eastern Hare-wallaby	presumed extinct	presumed extinct
Mammal	*Lasiorhinus krefftii*	Northern Hairy-nosed Wombat	presumed extinct	presumed extinct
Mammal	*Lasiorhinus latifrons*	Southern Hairy-nosed Wombat	data deficient	data deficient
Mammal	*Leggadina forresti*	Forrest's Mouse	data deficient	data deficient
Mammal	*Leporillus apicalis*	Lesser Stick-nest Rat	presumed extinct	presumed extinct
Mammal	*Leporillus conditor*	Greater Stick-nest Rat	presumed extinct	presumed extinct
Mammal	*Macropus dorsalis*	Black-striped Wallaby	data deficient	data deficient
Mammal	*Macropus fuliginosus*	Western Grey Kangaroo	no significant decline	sustainable
Mammal	*Macropus giganteus*	Eastern Grey Kangaroo	no significant decline	sustainable
Mammal	*Macropus parma*	Parma Wallaby	severe decline	data deficient
Mammal	*Macropus parryi*	Whiptail Wallaby	moderate decline	data deficient
Mammal	*Macropus robustus*	Common Wallaroo	no significant decline	data deficient
Mammal	*Macropus rufogriseus*	Red-necked Wallaby	no significant decline	data deficient
Mammal	*Macropus rufus*	Red Kangaroo	no significant decline	sustainable
Mammal	*Macrotis lagotis*	Bilby	presumed extinct	presumed extinct
Mammal	*Mastacomys fuscus*	Broad-toothed Rat	data deficient	data deficient
Mammal	*Melomys burtoni*	Grassland Melomys	no significant decline	data deficient
Mammal	*Melomys cervinipes*	Fawn-footed Melomys	severe decline	data deficient
Mammal	*Miniopterus australis*	Little Bentwing-bat	data deficient	data deficient
Mammal	*Miniopterus schreibersii oceanensis*	Eastern Bentwing-bat	no significant decline	data deficient

Class	Scientific name	Common name	Historic decline	Sustainability
Mammal	*Mormopterus "Species 2"*	Undescribed Freetail Bat	data deficient	data deficient
Mammal	*Mormopterus "Species 3" (little penis)*		data deficient	data deficient
Mammal	*Mormopterus "Species 4" (big penis)*		data deficient	data deficient
Mammal	*Mormopterus "Species 6"*	Hairy-nosed Freetail Bat	data deficient	data deficient
Mammal	*Mormopterus beccarii*	Beccari's Freetail-bat	data deficient	data deficient
Mammal	*Mormopterus norfolkensis*	Eastern Freetail-bat	data deficient	data deficient
Mammal	*Myotis adversus*	Large-footed Myotis	no significant decline	data deficient
Mammal	*Myrmecobius fasciatus*	Numbat	presumed extinct	presumed extinct
Mammal	*Ningaui yvonneae*	Southern Ningaui	data deficient	data deficient
Mammal	*Notomys cervinus*	Fawn Hopping-mouse	presumed extinct	presumed extinct
Mammal	*Notomys fuscus*	Dusky Hopping-mouse	data deficient	data deficient
Mammal	*Notomys longicaudatus*	Long-tailed Hopping-mouse	presumed extinct	presumed extinct
Mammal	*Notomys mitchellii*	Mitchell's Hopping-mouse	presumed extinct	presumed extinct
Mammal	*Nyctimene robinsoni*	Eastern Tube-nosed Bat	data deficient	data deficient
Mammal	*Nyctophilus bifax*	Eastern Long-eared Bat	no significant decline	data deficient
Mammal	*Nyctophilus geoffroyi*	Lesser Long-eared Bat	data deficient	data deficient
Mammal	*Nyctophilus gouldi*	Gould's Long-eared Bat	data deficient	data deficient
Mammal	*Nyctophilus howensis*	Lord Howe Island Bat	presumed extinct	presumed extinct
Mammal	*Nyctophilus timoriensis*	Eastern Long-eared Bat	data deficient	data deficient
Mammal	*Onychogalea fraenata*	Bridled Nailtail Wallaby	presumed extinct	presumed extinct
Mammal	*Onychogalea lunata*	Crescent Nailtail Wallaby	presumed extinct	presumed extinct
Mammal	*Ornithorhynchus anatinus*	Platypus	data deficient	data deficient
Mammal	*Perameles bougainville fasciata*	Western Barred Bandicoot (mainland)	presumed extinct	presumed extinct
Mammal	*Perameles nasuta*	Long-nosed Bandicoot	no significant decline	data deficient
Mammal	*Petauroides volans*	Greater Glider	no significant decline	data deficient
Mammal	*Petaurus australis*	Yellow-bellied Glider	no significant decline	data deficient
Mammal	*Petaurus breviceps*	Sugar Glider	data deficient	data deficient
Mammal	*Petaurus norfolcensis*	Squirrel Glider	data deficient	data deficient

Class	Scientific name	Common name	Historic decline	Sustainability
Mammal	*Petrogale penicillata*	Brush-tailed Rock-wallaby	moderate decline	data deficient
Mammal	*Petrogale xanthopus*	Yellow-footed Rock-wallaby	severe decline	substantial risk
Mammal	*Phascogale calura*	Red-tailed Phascogale	presumed extinct	presumed extinct
Mammal	*Phascogale tapoatafa*	Brush-tailed Phascogale	moderate decline	data deficient
Mammal	*Phascolarctos cinereus*	Koala	no significant decline	data deficient
Mammal	*Planigale gilesi*	Paucident Planigale	severe decline	data deficient
Mammal	*Planigale maculata*	Common Planigale	no significant decline	data deficient
Mammal	*Planigale tenuirostris*	Narrow-nosed Planigale	moderate decline	data deficient
Mammal	*Potorous longipes*	Long-footed Potoroo	severe decline	data deficient
Mammal	*Potorous tridactylus*	Long-nosed Potoroo	data deficient	data deficient
Mammal	*Pseudocheirus peregrinus*	Common Ringtail Possum	no significant decline	data deficient
Mammal	*Pseudomys apodemoides*	Silky Mouse	severe decline	data deficient
Mammal	*Pseudomys australis*	Plains Rat	presumed extinct	presumed extinct
Mammal	*Pseudomys bolami*	Bolam's Mouse	data deficient	data deficient
Mammal	*Pseudomys delicatulus*	Delicate Mouse	data deficient	data deficient
Mammal	*Pseudomys desertor*	Desert Mouse	presumed extinct	presumed extinct
Mammal	*Pseudomys fumeus*	Smoky Mouse	severe decline	substantial risk
Mammal	*Pseudomys gouldii*	Gould's Mouse	presumed extinct	presumed extinct
Mammal	*Pseudomys gracilicaudatus*	Eastern Chestnut Mouse	data deficient	data deficient
Mammal	*Pseudomys hermannsburgensis*	Sandy Inland Mouse	data deficient	data deficient
Mammal	*Pseudomys novaehollandiae*	New Holland Mouse	no significant decline	data deficient
Mammal	*Pseudomys oralis*	Hastings River Mouse	data deficient	data deficient
Mammal	*Pseudomys pilligaensis*	Pilliga Mouse	data deficient	data deficient
Mammal	*Pteropus alecto*	Black Flying-fox	no significant decline	sustainable
Mammal	*Pteropus poliocephalus*	Grey-headed Flying-fox	data deficient	data deficient
Mammal	*Pteropus scapulatus*	Little Red Flying-fox	no significant decline	data deficient
Mammal	*Rattus fuscipes*	Bush Rat	no significant decline	data deficient

Class	Scientific name	Common name	Historic decline	Sustainability
Mammal	*Rattus lutreolus*	Swamp Rat	data deficient	data deficient
Mammal	*Rattus tunneyi*	Pale Field-rat	data deficient	data deficient
Mammal	*Rattus villosissimus*	Long-haired Rat	data deficient	data deficient
Mammal	*Rhinolophus megaphyllus*	Eastern Horseshoe-bat	data deficient	data deficient
Mammal	*Saccolaimus flaviventris*	Yellow-bellied Sheathtail-bat	data deficient	data deficient
Mammal	*Scoteanax rueppellii*	Greater Broad-nosed Bat	data deficient	data deficient
Mammal	*Scotorepens balstoni*	Inland Broad-nosed Bat	data deficient	data deficient
Mammal	*Scotorepens greyii*	Little Broad-nosed Bat	data deficient	data deficient
Mammal	*Scotorepens orion*	Eastern Broad-nosed Bat	data deficient	data deficient
Mammal	*Scotorepens sp 1*	undescribed broad-nosed bat	data deficient	data deficient
Mammal	*Sminthopsis crassicaudata*	Fat-tailed Dunnart	severe decline	data deficient
Mammal	*Sminthopsis leucopus*	White-footed Dunnart	moderate decline	data deficient
Mammal	*Sminthopsis macroura*	Stripe-faced Dunnart	severe decline	data deficient
Mammal	*Sminthopsis murina*	Common Dunnart	data deficient	data deficient
Mammal	*Syconycteris australis*	Common Blossom-bat	severe decline	data deficient
Mammal	*Tachyglossus aculeatus*	Short-beaked Echidna	no significant decline	data deficient
Mammal	*Tadarida australis*	White-striped Freetail-bat	moderate decline	data deficient
Mammal	*Thylogale stigmatica*	Red-legged Pademelon	severe decline	data deficient
Mammal	*Thylogale thetis*	Red-necked Pademelon	moderate decline	data deficient
Mammal	*Trichosurus caninus*	Short-eared Possum	data deficient	data deficient
Mammal	*Trichosurus cunninghami*	Mountain Brushtail Possum	data deficient	data deficient
Mammal	*Trichosurus vulpecula*	Common Brushtail Possum	no significant decline	data deficient
Mammal	*Vespadelus baverstocki*	Inland Forest Bat	data deficient	data deficient
Mammal	*Vespadelus darlingtoni*	Large Forest Bat	data deficient	data deficient
Mammal	*Vespadelus pumilus*	Eastern Forest Bat	no significant decline	data deficient
Mammal	*Vespadelus regulus*	Southern Forest Bat	data deficient	data deficient
Mammal	*Vespadelus troughtoni*	Eastern Cave Bat	data deficient	data deficient
Mammal	*Vespadelus vulturnus*	Little Forest Bat	data deficient	data deficient

Class	Scientific name	Common name	Historic decline	Sustainability
Mammal	*Vombatus ursinus*	Common Wombat	no significant decline	data deficient
Mammal	*Wallabia bicolor*	Swamp Wallaby	no significant decline	data deficient
Reptile	*Acanthophis antarcticus*	Common Death Adder	moderate decline	data deficient
Reptile	*Acritoscincus duperreyi*	Eastern Three-lined Skink	no significant decline	data deficient
Reptile	*Acritoscincus platynota*	Red-throated Skink	data deficient	data deficient
Reptile	*Amphibolurus muricatus*	Jacky Lizard	data deficient	data deficient
Reptile	*Amphibolurus nobbi*	Nobbi	data deficient	data deficient
Reptile	*Anomalopus leuckartii*	Two-clawed Worm-skink	no significant decline	data deficient
Reptile	*Anomalopus mackayi*	Five-clawed Worm-skink	data deficient	data deficient
Reptile	*Anomalopus swansoni*	Punctate Worm-skink	no significant decline	data deficient
Reptile	*Anomalopus verreauxii*	Three-clawed Worm-skink	data deficient	data deficient
Reptile	*Antaresia maculosa*	Spotted Python	data deficient	data deficient
Reptile	*Aprasia inaurita*	Mallee Worm-lizard	data deficient	data deficient
Reptile	*Aprasia parapulchella*	Pink-tailed Legless Lizard	data deficient	data deficient
Reptile	*Aspidites ramsayi*	Woma	data deficient	data deficient
Reptile	*Austrelaps ramsayi*	Highland Copperhead	moderate decline	data deficient
Reptile	*Austrelaps superbus*	Lowland Copperhead	severe decline	data deficient
Reptile	*Boiga irregularis*	Brown Tree Snake	data deficient	data deficient
Reptile	*Brachyurophis australis*	Coral Snake	data deficient	data deficient
Reptile	*Cacophis harriettae*	White-crowned Snake	data deficient	data deficient
Reptile	*Cacophis krefftii*	Southern Dwarf Crowned Snake	severe decline	data deficient
Reptile	*Cacophis squamulosus*	Golden-crowned Snake	data deficient	data deficient
Reptile	*Calyptotis ruficauda*	Red-tailed Calyptotis	severe decline	data deficient
Reptile	*Calyptotis scutirostrum*	Scute-snouted Calyptotis	data deficient	data deficient
Reptile	*Caretta caretta*	Loggerhead Turtle	data deficient	data deficient
Reptile	*Carlia pectoralis*	Open-litter Rainbow-skink	data deficient	data deficient
Reptile	*Carlia tetradactyla*	Southern Rainbow-skink	no significant decline	data deficient
Reptile	*Carlia vivax*	Tussock Rainbow-skink	data deficient	data deficient

Class	Scientific name	Common name	Historic decline	Sustainability
Reptile	*Chelodina longicollis*	Eastern Snake-necked Turtle	no significant decline	data deficient
Reptile	*Chelonia mydas*	Green Turtle	data deficient	data deficient
Reptile	*Christinus guentheri*	Lord Howe Island Southern Gecko	data deficient	data deficient
Reptile	*Christinus marmoratus*	Marbled Gecko	moderate decline	data deficient
Reptile	*Coeranoscincus reticulatus*	Three-toed Snake-tooth Skink	severe decline	data deficient
Reptile	*Cryptoblepharus carnabyi*	Spiny-palmed Shinning-skink	no significant decline	data deficient
Reptile	*Cryptoblepharus plagiocephalus*	Callose-palmed Shinning-skink	data deficient	data deficient
Reptile	*Cryptoblepharus virgatus*	Cream-striped Shinning-skink	data deficient	data deficient
Reptile	*Cryptophis nigrescens*	Eastern Small-eyed Snake	no significant decline	data deficient
Reptile	*Ctenophorus decresii*	Tawny Crevice-dragon	data deficient	data deficient
Reptile	*Ctenophorus fordi*	Mallee Military Dragon	no significant decline	data deficient
Reptile	*Ctenophorus nuchalis*	Central Netted Dragon	no significant decline	data deficient
Reptile	*Ctenophorus pictus*	Painted Dragon	moderate decline	data deficient
Reptile	*Ctenotus allotropis*	Brown-blazed Wedgesnout Ctenotus	data deficient	data deficient
Reptile	*Ctenotus arcanus*	Arcane Ctenotus	data deficient	data deficient
Reptile	*Ctenotus atlas*	Southern Mallee Ctenotus	no significant decline	data deficient
Reptile	*Ctenotus brachyonyx*	Short-clawed Ctenotus	no significant decline	data deficient
Reptile	*Ctenotus brooksi*	Wedgesnout Ctenotus	data deficient	data deficient
Reptile	*Ctenotus eurydice*	Brown-backed Yellow-lined Ctenotus	data deficient	data deficient
Reptile	*Ctenotus ingrami*	Unspotted Yellow-sided Ctenotus	data deficient	data deficient
Reptile	*Ctenotus leonhardii*	Leonhardi's Ctenotus	moderate decline	data deficient
Reptile	*Ctenotus olympicus*		data deficient	data deficient
Reptile	*Ctenotus orientalis*		data deficient	data deficient
Reptile	*Ctenotus pantherinus ocellifer*	Leopard Ctenotus	severe decline	data deficient

Class	Scientific name	Common name	Historic decline	Sustainability
Reptile	*Ctenotus regius*	Pale-rumped Ctenotus	moderate decline	data deficient
Reptile	*Ctenotus robustus*	Robust Ctenotus	no significant decline	data deficient
Reptile	*Ctenotus schomburgkii*	Barred Wedgesnout Ctenotus	no significant decline	data deficient
Reptile	*Ctenotus strauchii*	Eastern Barred Wedgesnout Ctenotus	data deficient	data deficient
Reptile	*Ctenotus taeniolatus*	Copper-tailed Skink	data deficient	data deficient
Reptile	*Ctenotus uber*	Spotted Ctenotus	data deficient	data deficient
Reptile	*Cyclodina lichenigera*	Lord Howe Island Skink	data deficient	data deficient
Reptile	*Cyclodomorphus gerrardii*	Pink-tongued Lizard	moderate decline	data deficient
Reptile	*Cyclodomorphus melanops elongatus*	Mallee Slender Blue-tongue Lizard	data deficient	data deficient
Reptile	*Cyclodomorphus michaeli*	Mainland She-oak Skink	moderate decline	data deficient
Reptile	*Cyclodomorphus praealtus*	Alpine She-oak Skink	data deficient	data deficient
Reptile	*Cyclodomorphus venustus*		data deficient	data deficient
Reptile	*Delma australis*	Marble-faced Delma	data deficient	data deficient
Reptile	*Delma butleri*	Unbanded Delma	data deficient	data deficient
Reptile	*Delma impar*	Striped Legless Lizard	data deficient	data deficient
Reptile	*Delma inornata*	Patternless Delma	severe decline	data deficient
Reptile	*Delma plebeia*	Leaden Delma	data deficient	data deficient
Reptile	*Delma tincta*	Excitable Delma	data deficient	data deficient
Reptile	*Demansia psammophis*	Yellow-faced Whip Snake	no significant decline	data deficient
Reptile	*Demansia torquata*	Collared Whip Snake	data deficient	data deficient
Reptile	*Dendrelaphis punctulatus*	Common Tree Snake	data deficient	data deficient
Reptile	*Denisonia devisi*	De Vis' Banded Snake	data deficient	data deficient
Reptile	*Dermochelys coriacea*	Leathery Turtle	data deficient	data deficient
Reptile	*Diplodactylus byrnei*	Gibber Gecko	no significant decline	data deficient
Reptile	*Diplodactylus conspicillatus*	Fat-tailed Diplodactylus	data deficient	data deficient
Reptile	*Diplodactylus elderi*	Jewelled Gecko	data deficient	data deficient
Reptile	*Diplodactylus steindachneri*	Box-patterned Gecko	data deficient	data deficient

Class	Scientific name	Common name	Historic decline	Sustainability
Reptile	*Diplodactylus stenodactylus*	Crowned Gecko	data deficient	data deficient
Reptile	*Diplodactylus tessellatus*	Tessellated Gecko	no significant decline	data deficient
Reptile	*Diplodactylus vittatus*	Wood Gecko	data deficient	data deficient
Reptile	*Diporiphora australis*	Tommy Roundhead	data deficient	data deficient
Reptile	*Drysdalia coronoides*	White-lipped Snake	moderate decline	data deficient
Reptile	*Drysdalia rhodogaster*	Mustard-bellied Snake	moderate decline	data deficient
Reptile	*Echiopsis curta*	Bardick	severe decline	data deficient
Reptile	*Egernia coventryi*	Eastern Mourning Skink	data deficient	data deficient
Reptile	*Egernia cunninghami*	Cunningham's Skink	no significant decline	data deficient
Reptile	*Egernia frerei*	Major Skink	data deficient	data deficient
Reptile	*Egernia guthega*		data deficient	data deficient
Reptile	*Egernia inornata*	Desert Skink	data deficient	data deficient
Reptile	*Egernia major*	Land Mullet	moderate decline	data deficient
Reptile	*Egernia mcpheei*	Eastern Crevice Skink	moderate decline	data deficient
Reptile	*Egernia modesta*	Eastern Ranges Rock-skink	moderate decline	data deficient
Reptile	*Egernia montana*		data deficient	data deficient
Reptile	*Egernia saxatilis*	Black Rock Skink	data deficient	data deficient
Reptile	*Egernia stokesii*	Gidgee Skink	data deficient	data deficient
Reptile	*Egernia striolata*	Tree Skink	no significant decline	data deficient
Reptile	*Egernia whitii*	White's Skink	data deficient	data deficient
Reptile	*Elseya belli*	Bell's Turtle	data deficient	data deficient
Reptile	*Elseya georgesi*	George's Turtle	data deficient	data deficient
Reptile	*Elseya latisternum*	Saw-shelled Turtle	data deficient	data deficient
Reptile	*Elseya purvisi*	Purvis' Turtle	data deficient	data deficient
Reptile	*Emydura macquarii*	Murray Turtle	moderate decline	data deficient
Reptile	*Eremiascincus fasciolatus*	Narrow-banded Sand-swimmer	data deficient	data deficient
Reptile	*Eremiascincus richardsonii*	Broad-banded Sand-swimmer	moderate decline	data deficient
Reptile	*Eulamprus heatwolei*	Yellow-bellied Water-skink	data deficient	data deficient
Reptile	*Eulamprus kosciuskoi*	Alpine Water Skink	data deficient	data deficient

Class	Scientific name	Common name	Historic decline	Sustainability
Reptile	*Eulamprus leuraensis*	Blue Mountains Water skink	data deficient	data deficient
Reptile	*Eulamprus martini*	Dark Barsided Skink	no significant decline	data deficient
Reptile	*Eulamprus murrayi*	Murray's Skink	data deficient	data deficient
Reptile	*Eulamprus quoyii*	Eastern Water-skink	no significant decline	data deficient
Reptile	*Eulamprus tenuis*	Barred-sided Skink	data deficient	data deficient
Reptile	*Eulamprus tryoni*	Tryon's Skink	data deficient	data deficient
Reptile	*Eulamprus tympanum*	Southern Water-skink	data deficient	data deficient
Reptile	*Furina diadema*	Red-naped Snake	moderate decline	data deficient
Reptile	*Furina dunmalli*	Dunmall's Snake	data deficient	data deficient
Reptile	*Gehyra dubia*	Dubious Dtella	data deficient	data deficient
Reptile	*Gehyra variegata*	Tree Dtella	no significant decline	data deficient
Reptile	*Harrisoniascincus zia*	Rainforest Cool-skink	severe decline	data deficient
Reptile	*Hemiaspis damelii*	Grey Snake	data deficient	data deficient
Reptile	*Hemiaspis signata*	Black-bellied Swamp Snake	moderate decline	data deficient
Reptile	*Hemiergis decresiensis*	Three-toed Earless Skink	no significant decline	data deficient
Reptile	*Hemiergis millewae*	Triodia Earless Skink	data deficient	data deficient
Reptile	*Heteronotia binoei*	Bynoe's Gecko	no significant decline	data deficient
Reptile	*Hoplocephalus bitorquatus*	Pale-headed Snake	severe decline	data deficient
Reptile	*Hoplocephalus bungaroides*	Broad-headed Snake	no significant decline	data deficient
Reptile	*Hoplocephalus stephensii*	Stephens' Banded Snake	no significant decline	data deficient
Reptile	*Hypsilurus spinipes*	Southern Angle-headed Dragon	data deficient	data deficient
Reptile	*Lampropholis amicula*	Friendly Sunskink	moderate decline	data deficient
Reptile	*Lampropholis caligula*	Montane Sunskink	moderate decline	data deficient
Reptile	*Lampropholis delicata*	Dark-flecked Garden Sunskink	no significant decline	data deficient
Reptile	*Lampropholis elongata*		data deficient	data deficient

Class	Scientific name	Common name	Historic decline	Sustainability
Reptile	*Lampropholis guichenoti*	Pale-flecked Garden Sunskink	no significant decline	data deficient
Reptile	*Lerista bougainvillii*	South-eastern Slider	data deficient	data deficient
Reptile	*Lerista labialis*	Southern Sandslider	no significant decline	data deficient
Reptile	*Lerista muelleri*	Wood Mulch-slider	no significant decline	data deficient
Reptile	*Lerista punctatovittata*	Eastern Robust Slider	no significant decline	data deficient
Reptile	*Lerista xanthura*	Yellow-tailed Plain Slider	data deficient	data deficient
Reptile	*Lialis burtonis*	Burton's Snake-lizard	severe decline	data deficient
Reptile	*Liasis stimsoni*	Stimson's Python	data deficient	data deficient
Reptile	*Lophognathus burnsi*	Burns' Dragon	no significant decline	data deficient
Reptile	*Lucasium damaeum*	Beaded Gecko	data deficient	data deficient
Reptile	*Lygisaurus foliorum*	Tree-base Litter-skink	data deficient	data deficient
Reptile	*Macrochelodina expansa*	Broad-shelled River Turtle	data deficient	data deficient
Reptile	*Menetia greyii*	Common Dwarf Skink	data deficient	data deficient
Reptile	*Morelia spilota*	Carpet & Diamond Pythons	data deficient	data deficient
Reptile	*Morethia adelaidensis*	Saltbush Morethia Skink	no significant decline	data deficient
Reptile	*Morethia boulengeri*	South-eastern Morethia Skink	no significant decline	data deficient
Reptile	*Morethia obscura*	Shrubland Morethia Skink	data deficient	data deficient
Reptile	*Nannoscincus maccoyi*	Highlands Forest-skink	data deficient	data deficient
Reptile	*Nephrurus levis*	Three-lined Knob-tail	no significant decline	data deficient
Reptile	*Niveoscincus coventryi*	Southern Forest Cool-skink	data deficient	data deficient
Reptile	*Notechis scutatus*	Tiger Snake	no significant decline	data deficient
Reptile	*Oedura lesueurii*	Lesueur's Velvet Gecko	data deficient	data deficient
Reptile	*Oedura marmorata*	Marbled Velvet Gecko	moderate decline	data deficient
Reptile	*Oedura monilis*	Ocellated Velvet Gecko	data deficient	data deficient
Reptile	*Oedura rhombifer*	Zigzag Velvet Gecko	data deficient	data deficient

Class	Scientific name	Common name	Historic decline	Sustainability
Reptile	*Oedura robusta*	Robust Velvet Gecko	data deficient	data deficient
Reptile	*Oedura tryoni*	Southern Spotted Velvet Gecko	no significant decline	data deficient
Reptile	*Ophioscincus truncatus*	Short-limbed Snake-skink	data deficient	data deficient
Reptile	*Oxyuranus microlepidotus*	Fierce Snake	presumed extinct	presumed extinct
Reptile	*Oxyuranus scutellatus*	Taipan	data deficient	data deficient
Reptile	*Parasuta dwyeri*	Dwyer's Snake	severe decline	data deficient
Reptile	*Parasuta nigriceps*	Mitchell's Short-tailed Snake	data deficient	data deficient
Reptile	*Parasuta spectabilis*	Mallee Black-headed Snake	data deficient	data deficient
Reptile	*Phyllurus platurus*	Broad-tailed Gecko	data deficient	data deficient
Reptile	*Physignathus lesueurii*	Eastern Water Dragon	no significant decline	data deficient
Reptile	*Pogona barbata*	Bearded Dragon	data deficient	data deficient
Reptile	*Pogona vitticeps*	Central Bearded Dragon	no significant decline	data deficient
Reptile	*Proablepharus kinghorni*	Red-tailed Soil-crevice Skink	data deficient	data deficient
Reptile	*Pseudechis australis*	King Brown Snake	moderate decline	data deficient
Reptile	*Pseudechis guttatus*	Spotted Black Snake	no significant decline	data deficient
Reptile	*Pseudechis porphyriacus*	Red-bellied Black Snake	data deficient	data deficient
Reptile	*Pseudemoia entrecasteauxii*	Tussock Cool-skink	data deficient	data deficient
Reptile	*Pseudemoia pagenstecheri*	Tussock Skink	no significant decline	data deficient
Reptile	*Pseudemoia rawlinsoni*	Swampland Cool-skink	data deficient	data deficient
Reptile	*Pseudemoia spenceri*	Trunk-climbing Cool-skink	moderate decline	data deficient
Reptile	*Pseudonaja modesta*	Ringed Brown Snake	data deficient	data deficient
Reptile	*Pseudonaja nuchalis*	Western Brown Snake	moderate decline	data deficient
Reptile	*Pseudonaja textilis*	Eastern Brown Snake	no significant decline	data deficient
Reptile	*Pygopus lepidopodus*	Common Scaly-foot	moderate decline	data deficient
Reptile	*Pygopus schraderi*	Eastern Hooded Scaly-foot	severe decline	data deficient

Class	Scientific name	Common name	Historic decline	Sustainability
Reptile	*Ramphotyphlops affinis*	Small-headed Blind Snake	data deficient	data deficient
Reptile	*Ramphotyphlops batillus*		data deficient	data deficient
Reptile	*Ramphotyphlops bicolor*		data deficient	data deficient
Reptile	*Ramphotyphlops bituberculatus*	Prong-snouted Blind Snake	moderate decline	data deficient
Reptile	*Ramphotyphlops endoterus*	Interior Blind Snake	data deficient	data deficient
Reptile	*Ramphotyphlops ligatus*	Robust Blind Snake	data deficient	data deficient
Reptile	*Ramphotyphlops nigrescens*	Blackish Blind Snake	data deficient	data deficient
Reptile	*Ramphotyphlops proximus*	Proximus Blind Snake	severe decline	data deficient
Reptile	*Ramphotyphlops wiedii*	Brown-snouted Blind Snake	severe decline	data deficient
Reptile	*Rankinia diemensis*	Mountain Dragon	no significant decline	data deficient
Reptile	*Rhynchoedura ornata*	Beaked Gecko	data deficient	data deficient
Reptile	*Saiphos equalis*	Three-toed Skink	moderate decline	data deficient
Reptile	*Saltuarius swaini*	Southern Leaf-tailed Gecko	moderate decline	data deficient
Reptile	*Saltuarius wyberba*		data deficient	data deficient
Reptile	*Saproscincus challengeri*	Orange-tailed Shadeskink	data deficient	data deficient
Reptile	*Saproscincus mustelinus*	Weasel Skink	no significant decline	data deficient
Reptile	*Saproscincus oriarus*		data deficient	data deficient
Reptile	*Saproscincus rosei*	Orange-tailed Shadeskink	severe decline	data deficient
Reptile	*Saproscincus spectabilis*	Pale-lipped Shadeskink	severe decline	data deficient
Reptile	*Simoselaps fasciolatus*	Narrow-banded Snake	data deficient	data deficient
Reptile	*Strophurus ciliaris*	Spiny-tailed Gecko	severe decline	data deficient
Reptile	*Strophurus intermedius*	Southern Spiny-tailed Gecko	no significant decline	data deficient
Reptile	*Strophurus williamsi*	Eastern Spiny-tailed Gecko	moderate decline	data deficient
Reptile	*Suta flagellum*	Little Whip Snake	data deficient	data deficient
Reptile	*Suta suta*	Curl Snake	moderate decline	data deficient

Class	Scientific name	Common name	Historic decline	Sustainability
Reptile	*Tiliqua multifasciata*	Centralian Blue-tongued Lizard	severe decline	data deficient
Reptile	*Tiliqua nigrolutea*	Blotched Blue-tongue	data deficient	data deficient
Reptile	*Tiliqua occipitalis*	Western Blue-tongued Lizard	data deficient	data deficient
Reptile	*Tiliqua rugosa*	Shingle-back	no significant decline	data deficient
Reptile	*Tiliqua scincoides*	Eastern Blue-tongue	data deficient	data deficient
Reptile	*Tropidechis carinatus*	Rough-scaled Snake	moderate decline	data deficient
Reptile	*Tropidonophis mairii*	Freshwater Snake	data deficient	data deficient
Reptile	*Tympanocryptis intima*	Gibber Earless Dragon	data deficient	data deficient
Reptile	*Tympanocryptis lineata*	Lined Earless Dragon	data deficient	data deficient
Reptile	*Tympanocryptis pinguicolla*	Grassland Earless Dragon	data deficient	data deficient
Reptile	*Tympanocryptis tetraporophora*	Eyrean Earless Dragon	data deficient	data deficient
Reptile	*Underwoodisaurus milii*	Thick-tailed Gecko	moderate decline	data deficient
Reptile	*Underwoodisaurus sphyrurus*	Border Thick-tailed Gecko	data deficient	data deficient
Reptile	*Varanus gouldii*	Gould's Goanna	no significant decline	data deficient
Reptile	*Varanus rosenbergi*	Rosenberg's Goanna	data deficient	data deficient
Reptile	*Varanus tristis*	Black-headed Monitor	data deficient	data deficient
Reptile	*Varanus varius*	Lace Monitor	data deficient	data deficient
Reptile	*Vermicella annulata*	Bandy-bandy	moderate decline	data deficient

Appendix 2: Criteria to assess the sustainability of fauna species

Definitions of terms follow IUCN (2001). These definitions are reproduced in Appendix 4

Criterion A: Current trend in distribution or abundance

A1. There is a current negative trend in a measure of distribution or abundance and the causes of the trend are understood, reversible and have ceased (including any lag effects):

		Sustainability
Reduction over 10 years	>90%	1 Severe risk
	>70%	2 Substantial risk
	>50%	3 Moderate risk
	>25%	4 Low risk
	≤25%	5 Sustainable

A2. There is a current negative trend in a measure of distribution or abundance and the causes of the trend may not have ceased (including any lag effects), may not be understood or may not be reversible:

		Sustainability
Reduction over 10 years	>80%	1 Severe risk
	>50%	2 Substantial risk
	>30%	3 Moderate risk
	>25%	4 Low risk
	≤25%	5 Sustainable

A2(i). There is a current negative trend in a measure of distribution or abundance, and there is evidence of long-term declines of >50% in distribution since European settlement, and the causes of the long-term trend may not have ceased (including any lag effects), may not be understood or may not be reversible:

		Sustainability
Reduction over 10 years	>50%	1 Severe risk
	>30%	2 Substantial risk
	>15%	3 Moderate risk
	>0%	4 Low risk
	≤0%	5 Sustainable

A3. A negative trend in a measure of distribution or abundance is projected or suspected to be met in the future (up to a maximum of 100 years):

		Sustainability
Reduction over 10 years	>80%	1 Severe risk
	>50%	2 Substantial risk
	>30%	3 Moderate risk
	>25%	4 Low risk
	≤25%	5 Sustainable

A4. There is a negative trend in a measure of distribution or abundance where the period of decline includes both the past and the future, and the causes of the decline may not have ceased (including any lag effects), may not be understood or may not be reversible:

		Sustainability
Reduction over 10 years	>80%	1 Severe risk
	>50%	2 Substantial risk
	>30%	3 Moderate risk
	>25%	4 Low risk
	≤25%	5 Sustainable

Criterion B: Limited geographic range

Either		**Sustainability**
B1. extent of occurrence:	<100 km^2	1 Severe risk
	<5000 km^2	2 Substantial risk
	<20,000 km^2	3 Moderate risk
	<40,000 km^2	4 Low risk
	>40,000 km^2	5 Sustainable
OR		
B2. area of occupancy:	<10 km^2	1 Severe risk
	<500 km^2	2 Substantial risk
	<2000 km^2	3 Moderate risk
	<4000 km^2	4 Low risk
	>4000 km^2	5 Sustainable

AND two of the following three:		**Sustainability**
(a) severely fragmented **OR** number of locations:	=1	1 Severe risk
	≤5	2 Substantial risk
	≤10	3 Moderate risk
(b) continuing decline in:	(i)	extent of occurrence
	(ii)	area of occupancy
	(iii)	area, extent or quality of habitat
	(iv)	number of locations or subpopulations
	(v)	number of mature individuals
(c) extreme fluctuations in any of:	(i)	extent of occurrence
	(ii)	area of occupancy
	(iii)	number of locations or subpopulations
	(iv)	number of mature individuals

Criterion C: Small population size

Where the current population size is small and there is a current downward trend in distribution or abundance

		Sustainability
Number of mature individuals:	<250	1 Severe risk
	<2500	2 Substantial risk
	<10,000	3 Moderate risk
	<20,000	4 Low risk
	>20,000	5 Sustainable

AND either C1 OR C2:

		Sustainability
C1. An estimated continuing decline of at least:	25% in three years	1 Severe risk
	20% in five years	2 Substantial risk
	10% in 10 years	3 Moderate risk
	5% in 20 years	4 Low risk
C2. A continuing decline **AND (a) OR (b)**		
(a i) # mature individuals in largest subpopulation:	<50	1 Severe risk

	<250	2 Substantial risk
	<1000	3 Moderate risk
OR		
(a ii) % mature individuals in one subpopulation:	90–100%	1 Severe risk
	95–100%	2 Substantial risk
	100%	3 Moderate risk
(b) extreme fluctuations in the number of mature individuals		

Criterion D: Very small or restricted population

No evidence of current decline required, but data on current population size or distribution must be available

		Sustainability
D1. Number of mature individuals:	<50	1 Severe risk
	<250	2 Substantial risk
	<1000	3 Moderate risk
	<2000	4 Low risk
OR		
D2. Restricted area of occupancy*:	<20 km^2	3 Moderate risk
	<40 km^2	4 Low risk

*sustainability of species threatened because of restricted area of occupancy

Criterion E: Quantitative analysis

Direct estimation of probability of extinction from demographic data (eg Population Viability Analysis)

		Sustainability
Probability of extinction:	50% in 10 years	1 Severe risk
	20% in 20 years	2 Substantial risk
	10% in 100 years	3 Moderate risk
	5% in 100 years	4 Low risk

IUCN 2001, *IUCN Red List Categories and Criteria: Version 3.1,* IUCN Species Survival Commission, IUCN, Gland, Switzerland and Cambridge, UK.

Appendix 3: Regional assessment of sustainability

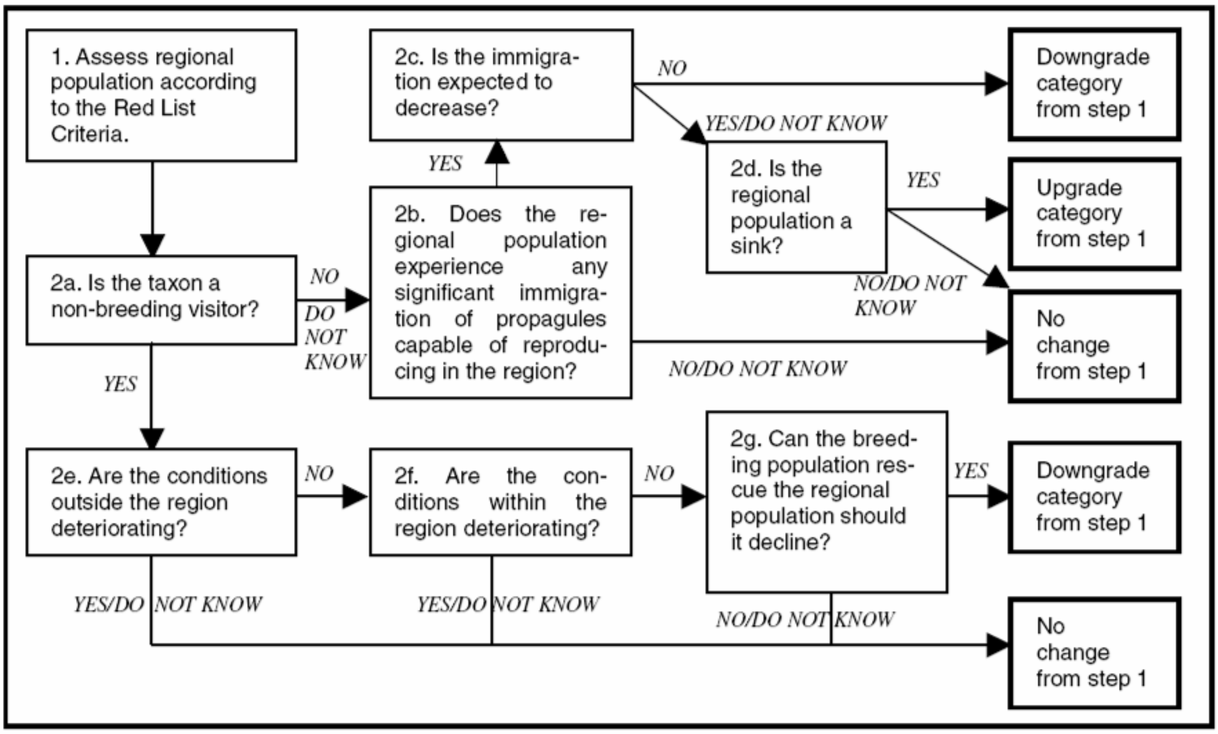

Figure from IUCN (2003)

IUCN 2003, *Guidelines for Application of IUCN Red List Criteria at Regional Levels: Version 3.0,* IUCN Species Survival Commission, IUCN, Gland, Switzerland and Cambridge, UK.

Appendix 4: Definitions of terms used in the IUCN criteria

All definitions are from IUCN (2001)

Population and population size (Criteria A, C and D)

The term 'population' is used in a specific sense in the Red List Criteria that is different to its common biological usage. Population is here defined as the total number of individuals of the taxon. For functional reasons, primarily owing to differences between life forms, population size is measured as numbers of mature individuals only. In the case of taxa obligately dependent on other taxa for all or part of their life cycles, biologically appropriate values for the host taxon should be used.

Subpopulations (Criteria B and C)

Subpopulations are defined as geographically or otherwise distinct groups in the population between which there is little demographic or genetic exchange (typically one successful migrant individual or gamete per year or less).

Mature individuals (Criteria A, B, C and D)

The number of mature individuals is the number of individuals known, estimated or inferred to be capable of reproduction. When estimating this quantity, the following points should be borne in mind:

- Mature individuals that will never produce new recruits should not be counted (eg densities are too low for fertilisation).
- In the case of populations with biased adult or breeding sex ratios, it is appropriate to use lower estimates for the number of mature individuals, which take this into account.
- Where the population size fluctuates, use a lower estimate. In most cases this will be much less than the mean.
- Reproducing units within a clone should be counted as individuals, except where such units are unable to survive alone (eg corals).
- In the case of taxa that naturally lose all or a subset of mature individuals at some point in their life cycle, the estimate should be made at the appropriate time, when mature individuals are available for breeding.
- Reintroduced individuals must have produced viable offspring before they are counted as mature individuals.

Generation (Criteria A, C and E)

Generation length is the average age of parents of the current cohort (ie newborn individuals in the population). Generation length therefore reflects the turnover rate of breeding individuals in a population. Generation length is greater than the age at first breeding and less than the age of the oldest breeding individual, except in taxa that breed only once. Where generation length varies under threat, the more natural, ie pre-disturbance, generation length should be used.

Reduction (Criterion A)

A reduction is a decline in the number of mature individuals of at least the amount (per cent) stated under the criterion over the time period (years) specified, although the decline need not be continuing. A reduction should not be interpreted as part of a fluctuation unless there is good evidence for this. The downward phase of a fluctuation will not normally count as a reduction.

Continuing decline (Criteria B and C)

A continuing decline is a recent, current or projected future decline (which may be smooth, irregular or sporadic) which is liable to continue unless remedial measures are taken. Fluctuations will not normally count as continuing declines, but an observed decline should not be considered as a fluctuation unless there is evidence for this.

Extreme fluctuations (Criteria B and C)

Extreme fluctuations can be said to occur in a number of taxa when population size or distribution area varies widely, rapidly and frequently, typically with a variation greater than one order of magnitude (ie a tenfold increase or decrease).

Severely fragmented (Criterion B)

The phrase 'severely fragmented' refers to the situation in which increased extinction risk to the taxon results from the fact that most of its individuals are found in small and relatively isolated subpopulations (in certain circumstances this may be inferred from habitat information). These small subpopulations may go extinct, with a reduced probability of recolonisation.

Extent of occurrence (Criteria A and B)

Extent of occurrence is defined as the area contained within the shortest continuous imaginary boundary which can be drawn to encompass all the known, inferred or projected sites of present occurrence of a taxon, excluding cases of vagrancy. This measure may exclude discontinuities or disjunctions within the overall distributions of taxa, eg large areas of obviously unsuitable habitat (but see 'area of occupancy' … below). Extent of occurrence can often be measured by a minimum convex polygon (the smallest polygon in which no internal angle exceeds 180 degrees and which contains all the sites of occurrence).

Area of occupancy (Criteria A, B and D)

Area of occupancy is defined as the area within its 'extent of occurrence' … which is occupied by a taxon, excluding cases of vagrancy. … The measure reflects the fact that a taxon will not usually occur throughout the area of its extent of occurrence, which may contain unsuitable or unoccupied habitats. In some cases (eg irreplaceable colonial nesting sites, crucial feeding sites for migratory taxa) the area of occupancy is the smallest area essential at any stage to the survival of existing populations of a taxon. The size of the area of occupancy will be a function of the scale at which it is measured, and should be at a scale appropriate to relevant biological aspects of the taxon, the nature of threats and the available data. … To avoid inconsistencies and bias in assessments caused by estimating area of occupancy at different scales, it may be necessary to standardise estimates by applying a scale-correction factor. It is difficult to give strict guidance on how standardisation should be done, as different types of taxa have different scale-area relationships.

Location (Criteria B and D)

The term 'location' defines a geographically or ecologically distinct area in which a single threatening event can rapidly affect all individuals of the taxon present. The size of the location depends on the area covered by the threatening event and may include part of one or many subpopulations. Where a taxon is affected by more than one threatening event, location should be defined by considering the most serious plausible threat.

Quantitative analysis (Criterion E)

A quantitative analysis is defined here as any form of analysis which estimates the extinction probability of a taxon based on known life history, habitat requirements, threats and any specified management options. Population viability analysis (PVA) is one such technique. Quantitative analyses should make full use of all relevant available data. In a situation in which there is limited information, such data as are available can be used to provide an estimate of extinction risk (for instance, estimating the impact of stochastic events on habitat). In presenting the results of quantitative analyses, the assumptions (which must be appropriate and defensible), the data used and the uncertainty in the data or quantitative model must be documented.

IUCN 2001, *IUCN Red List Categories and Criteria: Version 3.1,* IUCN Species Survival Commission, IUCN, Gland, Switzerland and Cambridge, UK.

Appendix 5: Trial targeted monitoring: long-nosed potoroo

Objective

This project trialled a protocol for measuring long-term trends in the distribution of selected threatened marsupials in eastern NSW. The protocol uses motion-triggered cameras to detect target species at sampling points, and measures change in distribution as the change in site occupancy over time. The project is one of a series of long-term monitoring programs proposed to fill significant gaps in our knowledge of the sustainability of fauna and threatened species throughout NSW. The target species for the trial year is the long-nosed potoroo (*Potorous tridactylus*).

Introduction

The long-nosed potoroo is a medium-sized ground-dwelling marsupial with a patchy distribution along the coast of south-eastern Australia from Queensland to western Victoria and Tasmania. It lives in thick groundcover in coastal heath and wet and dry sclerophyll forest, where it eats fungi, arthropods, fruits, seeds and other plant material (Johnston 2008). The home range size of individuals is between two and 20 hectares (Claridge et al. 2007). It is listed as vulnerable under the *NSW Threatened Species Conservation Act 1995* and the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999.*

In this project we trialled a protocol to monitor changes in the distribution of the long-nosed potoroo in NSW. We selected one hundred sites within the NSW range of the species, each site being a 1 km x 1 km square, aligned north, south, east and west on a GDA 1994 Lambert Projection. Sites were sampled by four infrared triggered cameras placed in suitable baited locations within the cell. The cameras were left in place for two weeks.

Methods

Site selection

All possible 1 km x 1 km (100 ha) grid cells in NSW that contained suitable habitat for the long-nosed potoroo were identified before selecting the sampling sites. Grid cells were selected if they contained a recent record from the Atlas of NSW Wildlife, or if they contained known habitat or high-quality habitat as predicted from a habitat model. Atlas records were only used if the records were from 1996 or later, and were of observed or captured animals. The habitat models were DECC internal models, and grid cells were only selected if they contained at least 75 ha of high quality predicted habitat (ie more than 3/4 of the cell).

The set of selected grid cells were then culled on the basis of access, by eliminating those that did not contain roads or tracks.

A 20 km grid was used to ensure dispersion of the final one hundred sampling sites. We randomly selected one hundred of the 20 km grids that contained any of the selected 1 km grid cells (based on the habitat models and Wildlife Atlas records, there were 104 possible 20 km cells in NSW). We then selected a sampling site within each of the selected 20 km cells, in the following order of preference:

- A recent Wildlife Atlas record

- Known habitat
- High-quality predicted habitat.

Preference was also given to sites on public land.

The final sampling sites range along the coast of NSW from the Queensland border to the Victorian border (Figure A5-1; Table A5-1).

●= sampling site

Figure A5-1: Location of 100 sampling sites for long-nosed potoroo in NSW

Table A5-1: Location of long-nosed potoroo study sites in NSW. Coordinates are AGD66 zone 56

Site number	Site name	East	North	Reason for selection
1	Crown Land	547634	6884620	Wildlife Atlas record
2	Border Ranges NP	506987	6862300	High quality modelled habitat
3	Border Ranges NP; Mount Lindesay SF	475078	6861461	High-quality modelled habitat
4	Bald Knob SF	455170	6860328	Wildlife Atlas record
5	Wollumbin NP; Mount Warning NP	524078	6860288	High-quality modelled habitat
6	Border Ranges NP	492341	6856463	High-quality modelled habitat
7	Tooloom National Park	448422	6855952	High-quality modelled habitat
8	Tooloom NP	447544	6853902	High-quality modelled habitat
9	Border Ranges NP; Mebbin NP	513646	6850695	High-quality modelled habitat
10	Toonumbar NP	465808	6848955	High-quality modelled habitat
11	Toonumbar NP	473941	6846418	Wildlife Atlas record
12	Brunswick Heads NR; Tyagarah NR	553108	6841994	Known site
13	Nightcap NP	533195	6840840	High-quality modelled habitat
14	Nightcap NP; Whian Whian SCA	533309	6838847	Known site
15	Nightcap NP; Whian Whian SCA	531377	6837737	Wildlife Atlas record
16	Tyagarah NR	555505	6835142	Known site
17	Richmond Range NP	471692	6833306	Wildlife Atlas record
18	Yabbra NP	446802	6831886	High-quality modelled habitat
19	Richmond Range NP	476357	6821584	Wildlife Atlas record
20	Richmond Range NP	474882	6812505	Wildlife Atlas records
21	Boonoo SF	419440	6803357	High-quality modelled habitat
22	Other	542822	6795431	Predicted site
23	Demon NR	427711	6780837	Known site

Site number	Site name	East	North	Reason for selection
24	Ewingar SF	442884	6777700	Wildlife Atlas record
25	Washpool SF; Ewingar SF	444560	6765799	Wildlife Atlas record
26	Washpool NP; Gibraltar Range NP	435184	6737267	Known site
27	Yuraygir NP	530626	6729733	Predicted site
28	Gibraltar Range NP; Nymboida NP	441730	6727636	High-quality modelled habitat
29	Barool NP	422077	6721518	High-quality modelled habitat
30	Mount Mitchell SF	415097	6721125	High-quality modelled habitat
31	Nymboida NP; Dalmorton SF	433780	6709180	High-quality modelled habitat
32	Dalmorton SF	445201	6701828	High-quality modelled habitat
33	Yuraygir SCA	507832	6691407	Predicted site
34	Sherwood NR	500312	6682972	Known site
35	Chaelundi SF	447393	6680945	High-quality modelled habitat
36	Guy Fawkes River NP & SCA	437707	6675386	Wildlife Atlas record
37	Nymboi-Binderay NP; Clouds Creek SF	465976	6670994	Wildlife Atlas record
38	Mount Hyland NR; Marengo SF	444258	6665753	Known site
39	Dorrigo NP	483593	6642983	High-quality modelled habitat
40	Cunnawarra NP; Styx River SF	428917	6618834	High-quality modelled habitat
41	Styx River SF	423930	6618551	High-quality modelled habitat
42	Styx River SF	419279	6612278	High-quality modelled habitat
43	New England NP; Cunnawarra NP	434305	6612129	High-quality modelled habitat
44	Gumbaynggirr SCA; Dunggir NP	466581	6607973	Wildlife Atlas record
45	New England NP; Thumb Creek SF	457828	6603465	Wildlife Atlas record

Site number	Site name	East	North	Reason for selection
46	Carrai SCA	424408	6592545	High-quality modelled habitat
47	Yarrahapinni Wetlands NP	497125	6581683	Predicted site
48	Carrai SF	439694	6570383	High-quality modelled habitat
49	Werrikimbe NP	419982	6547226	High-quality modelled habitat
50	Mount Boss SF	440404	6540380	Wildlife Atlas record
51	Bellangry SF	457492	6539354	Wildlife Atlas record
52	Limeburners Creek NR	488301	6526094	Predicted site
53	Doyles River SF	424630	6518438	High-quality modelled habitat
54	Bulga SF	427370	6505576	Wildlife Atlas record
55	Bugan NR	405514	6502321	High-quality modelled habitat
56	Giro SF	386538	6501241	High-quality modelled habitat
57	Crowdy Bay NP	478267	6491458	Predicted site
58	Tapin Tops NP; Knorrit SF; Dingo SF	416236	6489912	High-quality modelled habitat
59	Khappinghat NR	450742	6464832	Wildlife Atlas record
60	Chichester SF	354712	6444307	High-quality modelled habitat
61	Chichester SF	376611	6444674	Wildlife Atlas record
62	Mount Royal NP	336130	6436236	Wildlife Atlas records
63	Booti Booti NP	455683	6431047	Predicted site
64	Ghin-Doo-Ee NP	416619	6430811	High-quality modelled habitat
65	Private; Chichester SF; Black Bulga SCA	386704	6428095	Wildlife Atlas record
66	Karuah NP	402637	6394934	Wildlife Atlas records
67	Heaton SF	354089	6350052	High-quality modelled habitat
68	Watagan SF	338283	6346103	Wildlife Atlas records
69	Jilliby SCA	346728	6338604	Wildlife Atlas records
70	Ourimbah SF	345110	6314451	High-quality modelled habitat
71	Budderoo NP	284551	6165571	Wildlife Atlas records

Site number	Site name	East	North	Reason for selection
72	Budderoo NP	291602	6164985	Probable site
73	Barren Grounds NR	289896	6159870	Wildlife Atlas records
74	Barren Grounds NR	290834	6160929	Wildlife Atlas records
75	Cambewarra Range NR	270495	6148712	High-quality modelled habitat
76	Jervis Bay NP	294817	6127078	High-quality modelled habitat
77	Jervis Bay NP	288583	6113686	High-quality modelled habitat
78	Yadboro SF	241403	6080839	Wildlife Atlas records
79	Moruya SF	234683	6008283	High-quality modelled habitat
80	Eurobodalla NP	241084	6001646	High-quality modelled habitat
81	Deua NP; Badja SF	192040	6000717	Wildlife Atlas records
82	Eurobodalla NP	240383	5996597	High-quality modelled habitat
83	Kooraban NP	219255	5981306	High-quality modelled habitat
84	Bodalla SF	230299	5980965	Wildlife Atlas records
85	Gulaga NP	229540	5976912	Known site
86	Wandella SF	211632	5974835	High-quality modelled habitat
87	Wadbilliga NP	206720	5956508	High-quality modelled habitat
88	Mimosa Rocks NP; Mumbulla SF	233328	5947088	Known site
89	Mimosa Rocks NP	230815	5938926	Known site
90	Ben Boyd NP	224814	5905522	Known site
91	Ben Boyd NP	225874	5904583	Known site
92	Ben Boyd NP; Bell Bird Creek NR	225298	5897542	Known site
93	Ben Boyd NP; East Boyd SF	229012	5885754	Known site
94	South East Forest NP	183435	5877976	Known site
95	Ben Boyd NP	235781	5873150	Known site
96	South East Forest NP	184795	5872058	Known site
97	Nadgee NR; Nadgee SF	226867	5871611	Known site

Site number	Site name	East	North	Reason for selection
98	Yambulla SF	197373	5862809	Wildlife Atlas record
99	Nadgee SF	215689	5857921	Wildlife Atlas records
100	Nadgee NR	229887	5854780	Known site

Sampling

We used PixController Digital Eye 7.2 camera units to sample the sites for the presence of long-nosed potoroos. The camera units comprise a weatherproof case containing a 7.2 megapixel digital camera and a passive infrared trigger (Figure A5-2).

Figure A5-2: Camera unit with passive infrared trigger, secured to a tree with a non-slip cable

Four camera units were placed in each 100 ha sampling site, in locations judged suitable by the staff in the field. Units were spaced as far apart as possible, having regard to accessibility. Camera units were attached to trees at waist height using a non-slip cable, and were aimed towards a bait station installed in the ground. The bait station was a 40 or 50 mm PVC vent cowl secured to the ground with tent pegs, which contained a mixture of peanut butter, rolled oats and honey. We splashed sesame oil around the bait station as a further attractant. Camera units were retrieved after 14 days.

Sampling of 41 of 100 sites occurred between March and June 2009. Data for a further eight sites were provided by DECC staff who were sampling independently in a manner that fulfilled our protocol.

Analysis

We conducted the following analyses:

- Proportion of sampled sites at which potoroos were detected
- Estimated occupancy rate
- The detection probability of potoroos

- Of the subset of sites with potoroos, the number of sites at which a potoroo was detected each day
- The proportion of the cameras at each site that detected potoroos.

Detection probability

The trial protocol used a sampling period of 14 days. To determine if this period was sufficient to detect potoroos reliably, we calculated the species' detection probability. Detection probability is the likelihood of detecting a species at a site, given that the species does occur there.

The analysis considers the presence or absence of potoroos at each site on each day. Results from the four cameras at each site were combined, to give a single sequence of presences and absences for each site over the sampling period.

Results from as many sites as possible were included in the analysis. Sites where no potoroos were detected were included in the analysis, as we know that every day represents an absence. Three sites where potoroos had been detected could not be included in the analysis, as we had not received the required data in time.

Detection probability was calculated using the program PRESENCE, implementing the binomial mixture method of MacKenzie et al. (2002). The probability was then used to construct a detectability curve using Equation 2 of Wintle et al. (2005).

Occupancy rate

PRESENCE was also used to calculate the estimated occupancy rate. The occupancy rate is the proportion of sites likely to contain potoroos, given that we may have failed to detect potoroos at some sites at which they were actually present.

Results

Occupied sites

Results were available for 49 sites at the end of June 2009. Long-nosed potoroos were detected at 13 (27 per cent) of these sites, namely sites 2, 19, 20, 22, 35, 36, 38, 62, 71, 73, 96, 97, 100 (Table A5-1).

Site-occupancy could be estimated for 46 of the 49 sites only because of missing data. The estimated site-occupancy rate across these sites was calculated as 22 per cent (± 0.06 s.e.) using PRESENCE, which is the same as the detected occupancy rate across the same sites of 10/46 = 22 per cent.

Detection probability

The single visit detection probability for potoroos was 36 per cent (based on the results from 46 sites for which appropriate data were available). That is, if a site contains potoroos, there is a 36 per cent chance that they will be detected in one night by sampling with four cameras. The probability of detection increases as more nights are sampled (Figure A5-3). A detection probability of 90 per cent is achieved after six days of sampling, and 99 per cent is achieved after 10 days.

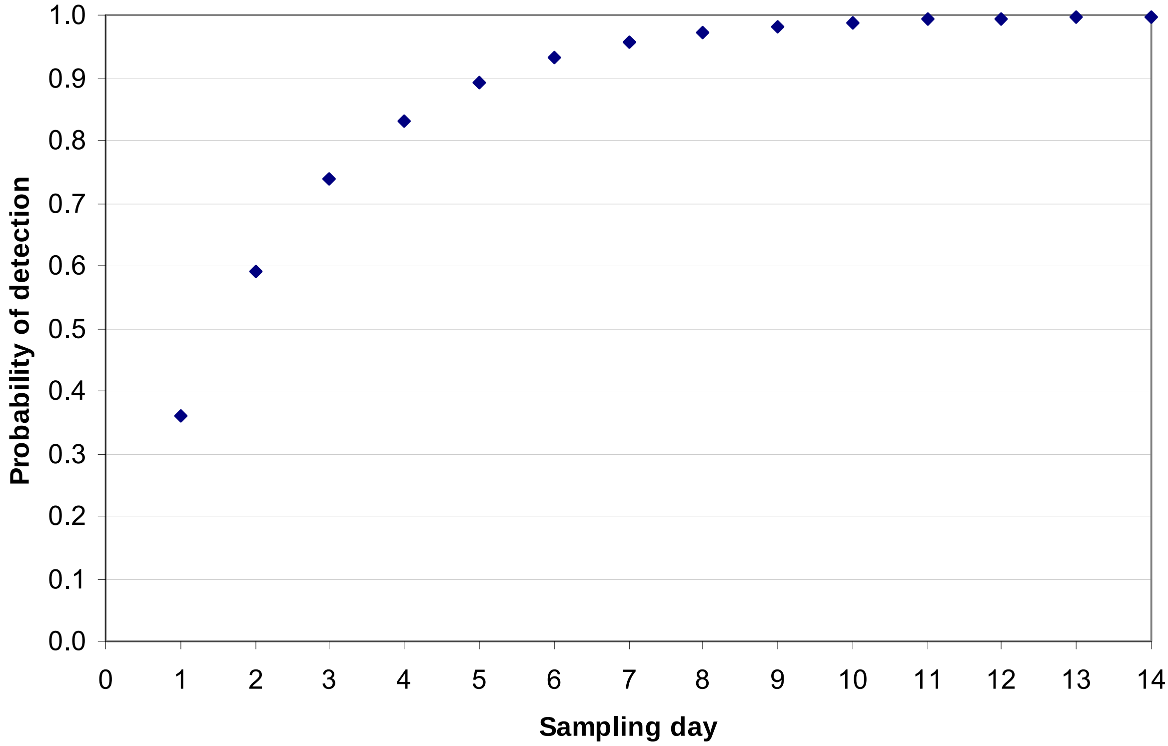

Figure A5-3: Detectability curve for the long-nosed potoroo in NSW

Note: Sampling is by four baited remote cameras within a 100 ha site

Sampling day

Potoroos were detected on all days of the sampling period (Figure A5-4). No trend in the proportion of detections each day was found using linear regression (y=0.0029x + 0.3371; r^2=0.0064), indicating that potoroos were just as likely to be detected early in the sampling period as late in the period.

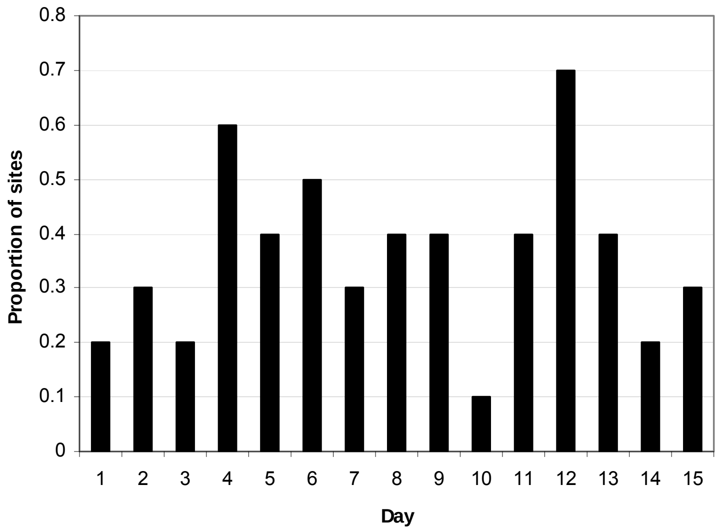

Figure A5-4: Proportion of sites where long-nosed potoroos were detected each day of the sampling period

Note: Only sites where potoroos were detected are included. A frequency of 1 occurs when potoroos are detected at all sites on a given day.

Proportion of cameras

Potoroos were not always detected by all cameras at a site. At sites where we did detect potoroos, the number of successful cameras ranged from 1–4, with an average of 2.3.

Other species

Many species other than the long-nosed potoroo were detected on the captured images. We were able to compile species lists for 31 sites. We did not attempt to identify small mammals such as rodents. In total, 39 species were identified to the species level (Table A5- 2). The species most commonly encountered was the Swamp Wallaby (*Wallabia bicolor*), which was detected at 21 sites.

Table A5-2: Species identified on remote camera images. Species lists were compiled for 31 sites

Common name	Scientific name	Number of sites
Swamp Wallaby	*Wallabia bicolour*	21
Long-nosed Bandicoot	*Perameles nasuta*	8
Northern Brown Bandicoot	*Isoodon macrourus*	8
Long-nosed Potoroo	*Potorous tridactylus*	7
Fox	*Vulpes vulpes*	7
Superb Lyrebird	*Menura novaehollandiae*	7
Common Brushtail Possum	*Trichosurus vulpecular*	5
Red-legged Pademelon	*Thylogale stigmatica*	4
Red-necked Wallaby	*Macropus rufogriseus*	4
Mountain Brushtail Possum	*Trichosurus cunninghami*	4
Short-beaked Echidna	*Tachyglossus aculeatus*	4
Australian Brush-turkey	*Alectura lathami*	3
Dog	*Canis lupus*	3
Common Wombat	*Vombatus ursinus*	3
Eastern Grey Kangaroo	*Macropus giganteus*	2
Common Ringtail Possum	*Pseudocheirus peregrinus*	2
Cow	*Bos taurus*	2
Alberts Lyrebird	*Menura alberti*	2
Satin Bowerbird	*Ptilonorhynchus violaceus*	2
Wonga Pigeon	*Leucosarcia melanoleuca*	2

Common name	Scientific name	Number of sites
New Holland Honeyeater	*Philidonyris novaehollandiae*	2
Red-bellied Black Snake	*Pseudechis porphyriacus*	2
Parma Wallaby	*Macropus parma*	1
Koala	*Phascolarctos cinereus*	1
Spotted-tailed Quoll	*Dasyurus maculatus*	1
Cat	*Felis catus*	1
Bassian Thrush	*Zoothera lunulata*	1
Eastern Whipbird	*Psophodes olivaceus*	1
Eastern Yellow Robin	*Eopsaltria australis*	1
Emu	*Dromaius novaehollandiae*	1
Green Catbird	*Ailuroedus crassirostris*	1
Grey Butcherbird	*Cracticus torquatus*	1
Grey Fantail	*Rhipidura albiscapa*	1
Laughing Kookaburra	*Dacelo novaeguineae*	1
Logrunner	*Orthonyx temminckii*	1
Noisy Pitta	*Pitta versicolor*	1
Pied Currawong	*Strepera graculina*	1
Torresian Crow	*Corvus orru*	1
Yellow-throated Scrubwren	*Sericornis citreogularis*	1

Discussion

We found the trial protocol to be satisfactory to monitor long-nosed potoroos in NSW. This adequacy was firstly shown by the detection of the species at 27 per cent of sampled sites. Secondly, the calculated detection probability suggests that after 14 days sampling, there was over a 99 per cent chance of detecting potoroos at sites at which they were present. Based on these results, we consider that the trialled protocol could be effectively applied in an ongoing potoroo monitoring program.

Occupied sites

It was not the aim of the project to detect potoroos at all of the sampled sites. Given that the purpose of a long-term monitoring program is to measure changes in distribution based on site occupancy, there needs to be scope for the number of occupied sites to decrease or increase. If potoroos were detected at all sites in the first year, there is then no ability for the program to measure possible subsequent increases in distribution. A potoroo monitoring program therefore needs to include sites with suitable habitat that might be populated by potoroos in the future.

Regardless, the number of sites where potoroos were detected could be increased, perhaps by re-examining the process used to select sites. A complicating factor was the different scales that need to be considered in the process, including of potoroo home ranges, the habitat models, and the 100 ha sampling sites. For example, this may have been a problem with sites selected for containing a recent Wildlife Atlas record. These sites were not overlain with the habitat model, so it is possible that little suitable habitat was present in the 100 ha site. This was less of a problem with sites selected on the basis of predicted habitat, as they were screened to only retain sites with at least 75 per cent coverage of predicted high-quality habitat. Even so, it was possible that at these sites the accessible areas in which the cameras were placed did not match the areas of suitable habitat.

Length of sampling

The detection probability analysis showed that sampling for two weeks was more than adequate. After 14 days the probability of detecting potoroos, if present, was greater than 99 per cent. Little would therefore be gained by sampling for longer than two weeks, particularly as longer sampling increases the risk of equipment failure or vandalism.

Two weeks is long enough to detect potoroos if present, but what is the minimum time required? The answer depends on the required confidence that an absence of potoroos is likely to be a genuine absence. For example, the detection probability after seven days is 96 per cent. This suggests that on average, potoroos will fail to be detected at one in twenty five sites at which they are present if sampling is only for one week. Indeed, an inspection of our data reveals that sampling for only one week would have missed potoroos at two of our sampled sites, at which potoroos were not detected until day 12. Regardless of this, the detection probability after 10 days is 99 per cent, and we suggest that this might be an appropriate lower limit. Detection probability changes with environmental conditions, so a longer sampling time allows more scope for potoroos to be detected despite poor sampling conditions.

There is a trade-off between length of sampling at each site and the number of sites that can be sampled in a given time period. No extra effort is required to sample for longer time periods (but beyond two weeks the camera battery may need to be changed). Considering all of the above, we recommend that sampling should be for 14 days, unless a program built around sampling for 10–13 days has substantial benefits as measured by the number of sites able to be sampled.

Number of cameras

The use of four cameras at each site was sufficient to detect potoroos with a high detection probability. Are four cameras at each site therefore required? Of those sites at which potoroos were detected, on average 2.3 cameras captured images of the species. We can consider what our results would have been had we used fewer cameras than four at each site we sampled. For example, consider the use of three cameras. At sites where potoroos were detected by four cameras, the use of three cameras would have detected the species. The same holds for sites where potoroos were detected by three cameras, or by two (three cameras cannot miss potoroos occurring at two out of four locations). However, at sites where potoroos were only detected on one camera out of four, then it is possible that the three cameras may have missed the species entirely. This would happen, on average, 25 per cent of the time. Of the 13 sites where we detected potoroos, there were three sites where only one camera detected the species. It is therefore possible that potoroos would not have been detected at some of these three sites had only three cameras been used. The use of only two cameras cannot be recommended, as doing so would have potentially missed detecting potoroos at nine of the successful 13 sites, according to the logic outlined above.

Reducing the number of cameras at each site would also reduce the detection probability. This then increases the number of days sampling required to achieve a given detection probability. It is possible to model the trade-off between number of cameras and number of days, but we did not have time to do these analyses. Regardless, we suggest that the protocol should remain the use of four cameras, unless the use of three leads to substantial logistical benefits in terms of the number of sites able to be sampled in a given time period.

The use of fewer than four cameras can have logistical benefits for both saving time in the field, and allowing more sites to be sampled simultaneously. However, using fewer cameras achieves little saving of time, given that the greatest time taken in the field work is travelling to and between sites, rather than installing and retrieving cameras. The time taken to install or retrieve the fourth camera is approximately twenty minutes. Thus the only benefit of three rather than four cameras is that extra sites can be sampled with the spare cameras. Using three cameras per site allows four sites to be sampled with 12 cameras, rather than three sites with four cameras.

The use of four cameras also provides insurance against camera failure. We found cameras to fail during the project for a number of reasons, both mechanical and operator error (see the 'Sampling protocol' section below for more discussion of camera failure). For this reason, we recommend continuing the use of four cameras per site.

Sampling protocol

A number of cameras failed to take acceptable images throughout the project for a number of reasons: flat batteries, incorrect installation resulting in poor field of view, and false triggering.

We found that the batteries in the camera and the infrared sensor were adequate to last two weeks. Some camera batteries were drained before this time if an excessive number of images, such as over 500, were falsely triggered. We also found some of the sensor batteries to fail after about three weeks, even though the camera documentation claims that the battery should last at least three months. We adopted a cautious approach, and changed the sensor battery before reusing a camera unit.

False triggering of the camera units appeared to be caused by the following reasons: the tree to which the camera unit was attached moved in the wind, vegetation close to the camera unit waved in the wind, or sunbeams moved across the field of view, or directly struck the infrared sensor. These problems can be largely avoided through careful camera placement.

The bait contained within the bait stations did not often last the two weeks of sampling. Sometimes the bait was absent, though there was no disturbance to the bait station. We think that in these instances the bait was either taken by insects, or washed away by rain. Sometimes the PVC vent cowl covering the bait was chewed through by rodents, and the bait stolen. Other times the entire bait station was pulled from the ground, or the ground excavated beneath the station. We recommend that alternative designs of bait stations are investigated to minimise these problems.

Regardless of the loss of the bait before the end of the sampling period, we found that there was not a significant trend in the day on which potoroos were detected. That is, potoroos were detected as often at the start of the two weeks as at the end. We therefore recommend that replacement of the bait after one week is unnecessary, particularly if an oil such as sesame or truffle oil is also applied to the ground near the bait station.

Other species

The protocol regularly detected species other than the target species, long-nosed potoroo (Table A5-2). The protocol was particularly effective at detecting medium-sized ground-dwelling mammals, such as bandicoots and wallabies, and large ground-dwelling birds such as lyrebirds. Many smaller species such as rats and antechinus were also detected, but could not be confidently identified in the images. We suggest that the protocol could be successfully applied to other medium-sized species, with appropriate consideration given to bait and site selection.

Required resources for future monitoring

Field work

We found that, on average, three sites could be established per field day, depending on the remoteness of the sites from the starting point and the distance between sites. Allowing for preparation and other office time between trips, we found that a team of two staff could set 8–9 sites per week (assuming three days' field work). Retrieval of cameras was quicker and it was typical to commence setting new sites in the same week as closing existing sites. Nevertheless, we suggest that the same time should be allowed also for the closure of sites. If two sets of sites are run concurrently (servicing each set in alternate weeks) then a team of two staff can survey 50 sites over a 12-week period (ie within a season). Hence we estimate that two teams of two are required to survey 100 sites within a season. Each team should be equipped to run two sets of sites simultaneously, requiring a minimum of 72 cameras per team.

Office work

The time taken to analyse the photos from the four cameras at each site varied with the number of photos taken, but it was typically about two hours. For 100 sites per year, this is 200 hours, or approximately 30 staff days.

Consumables

Consumables required for the project are bait (rolled oats, peanut butter, honey, sesame oil) and nine-volt batteries.

Recommendations for future monitoring

The protocol proved cost-effective for detecting long-nosed potoroos, and could form the basis of a long-term monitoring program. In order for it to do so, we recommend the following:

The selection of sites should be revised. For those sites at which potoroos were not detected, the site selection should be discussed with a local expert. The selection should focus on where suitable, accessible habitat occurs within the selected cells or alternative cells

- Sampling be for two weeks, unless sampling for 10–13 days allows substantially more sites to be sampled in the planned sampling season
- Sampling using four cameras
- Alternative designs for bait stations should be investigated.

Acknowledgements

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Appendix 6: Trial monitoring of amphibians, mammals and reptiles in the Western region

Introduction

Declines in native terrestrial vertebrates since European settlement have been greatest in western NSW (Section 2.3). Declines in mammals have been particularly severe, with almost half of all species either listed as presumed extinct or estimated to have lost at least half of their former range (see also Dickman et al. 1993). Despite this, almost no monitoring has been established to measure the sustainability of vertebrates in western NSW (Section 3.2). The Atlas of Australian Birds and aerial surveys of terrestrial wetlands provided estimates of trend for many species of birds, although trends could not be estimated reliably for all species. In contrast, no broad-scale monitoring data were available for any species of amphibian or reptile. All four species of mammals with adequate monitoring data are large macropods, three of which are abundant species subject to commercial harvesting. Given this paucity of information, the objective of this project was to trial methods that might be used to monitor trends in amphibians, mammals and reptiles at a regional scale. If successful, the trial could be expanded over time to form a regional fauna monitoring program.

Methods

Stratification of a population or area into relatively homogenous subgroups can improve the efficiency of sampling (Krebs 1989). For the purposes of the trial, the Western region was partitioned into 58 strata based on landforms and IBRA regions (Table A6-1; Figure A6-1). IBRA regions (version 6.1) were developed for the purposes of planning for conservation reserves (Thackway & Cresswell 1995; DEWHA 2009). They partition Australia based on predicted flora and fauna assemblages, geomorphology, climate and other attributes. At a finer scale, areas of similar topography, soil and vegetation in north-west NSW have been mapped into nine landforms and 251 landsystems (Walker 1991). Given the large number of strata, the trial sought to examine a subset of strata only. If the stratification reflects patterns in the distribution of fauna assemblages, then monitoring a subset of strata will result in efficient sampling of species associated with these strata. The number of strata targeted and species covered could be expanded over time as resources permit.

Ideally, sampling points should be distributed randomly or systematically throughout each of the strata; however, this presents several challenges. First, access to most of the region is limited. Approximately 96 per cent of the Western region is privately managed, and fauna survey may be not permitted in many areas. Similarly, access to public lands may be restricted by the availability of roads, risk to cultural heritage sites and other considerations. Second, sites will need to be clumped spatially if live-trapping is to be used and multiple sites are to be surveyed simultaneously. Given these factors, bias in sampling strata may be unavoidable.

For the trial, a cluster of 16 sites was established on conservation reserves within each of seven of the larger strata only (Table A6-1; Figure A6-2). The approximate locations of sites were chosen by local managers so as to minimise impacts on park values and other activities. Sites were placed adjacent to roads and spaced approximately 1 km apart. While these sites are likely to be a biased sample of each strata, they could provide a starting point for wider sampling within each strata and a reference for comparing areas within strata (eg comparing between areas subject to different land-use).

Table A6-1: A stratification of the Western region based on landforms (Walker 1991) and IBRA regions (Version 6.1; DEWHA 2009). Strata sampled in the trial are highlighted

IBRA region	Landform	% of IBRA region	Accumulative Sum
Broken Hill Complex	Rolling downs & lowlands	36.21	36
	Sandplains	22.74	59
	Ranges	14.79	74
	Alluvial plains	14.52	88
	Dunefields	5.86	94
	Hills & footslopes	2.81	97
	Tablelands	2.49	99
	Playas & basins	0.60	100
	Plains	0.00	100
Channel Country	Playas & basins	22.28	22
	Dunefields	21.71	44
	Rolling downs & lowlands	19.18	63
	Alluvial plains	14.94	78
	Tablelands	9.86	88
	Sandplains	7.73	96
	Hills & footslopes	2.92	99
	Ranges	1.44	100
Cobar Peneplain	Rolling downs & lowlands	45.85	46
	Plains	25.47	71
	Alluvial plains	9.79	81
	Hills & footslopes	8.77	90
	Ranges	8.62	99
	Dunefields	1.04	100
	Playas & basins	0.43	100
	Sandplains	0.02	100
	Tablelands	0.01	100
Darling Riverine Plains	Alluvial plains	87.69	88
	Playas & basins	5.63	93
	Dunefields	2.68	96
	Sandplains	2.09	98

IBRA region	Landform	% of IBRA region	Accumulative Sum
	Plains	1.32	99
	Rolling downs & lowlands	0.38	100
	Tablelands	0.17	100
	Ranges	0.06	100
	Hills & footslopes	0.02	100
Mulga Lands	Sandplains	27.10	27
	Rolling downs & lowlands	18.24	45
	Dunefields	16.92	62
	Alluvial plains	16.39	79
	Tablelands	6.29	85
	Hills & footslopes	5.22	90
	Plains	4.60	95
	Playas & basins	3.82	99
	Ranges	1.45	100
Murray Darling Depression	Sandplains	39.07	39
	Dunefields	34.41	73
	Plains	17.84	91
	Playas & basins	6.08	97
	Rolling downs & lowlands	0.91	98
	Alluvial plains	0.84	99
	Ranges	0.57	100
	Hills & footslopes	0.28	100
Simpson Strzelecki Dunefields	Dunefields	84.31	84
	Alluvial plains	9.43	94
	Playas & basins	3.78	98
	Rolling downs & lowlands	1.53	99
	Sandplains	0.55	100
	Tablelands	0.42	100

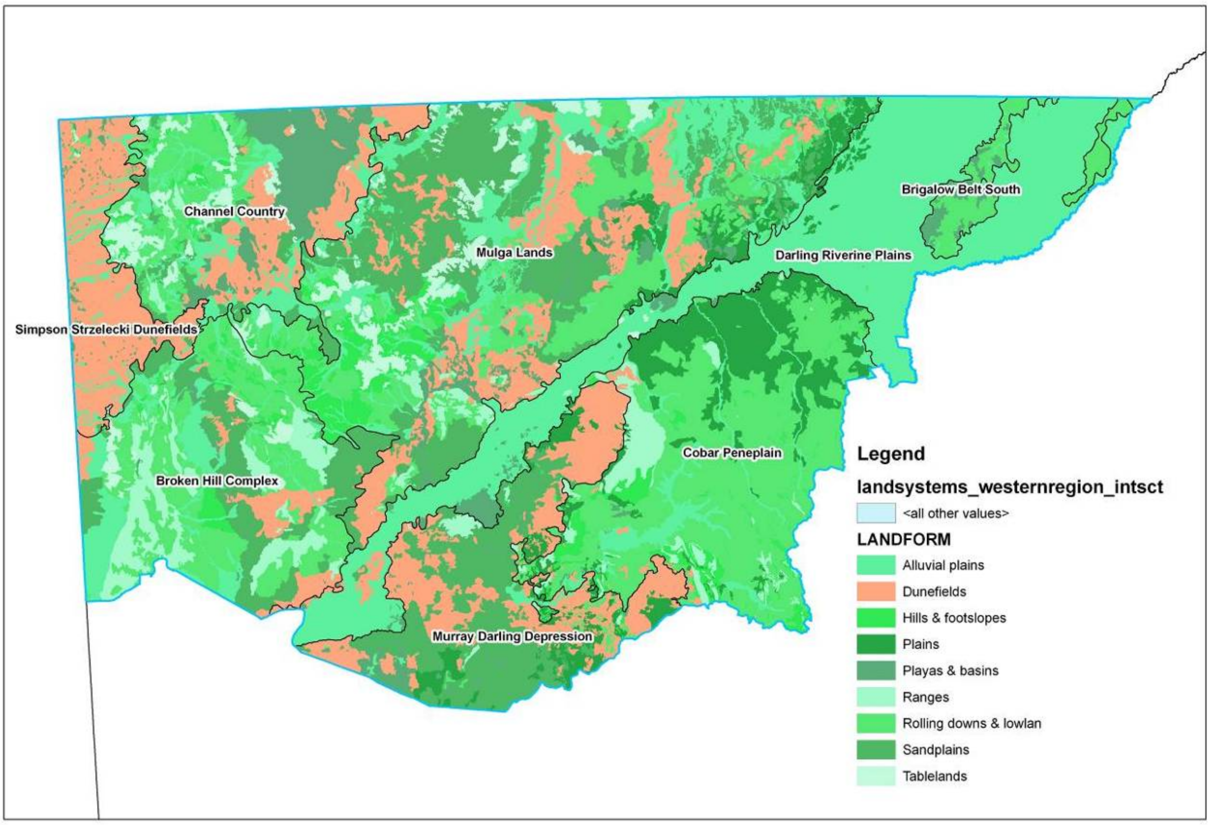

Figure A6-1: Stratification of the Western region by landform (Walker 1991) and IBRA region (DEWHA 2009)

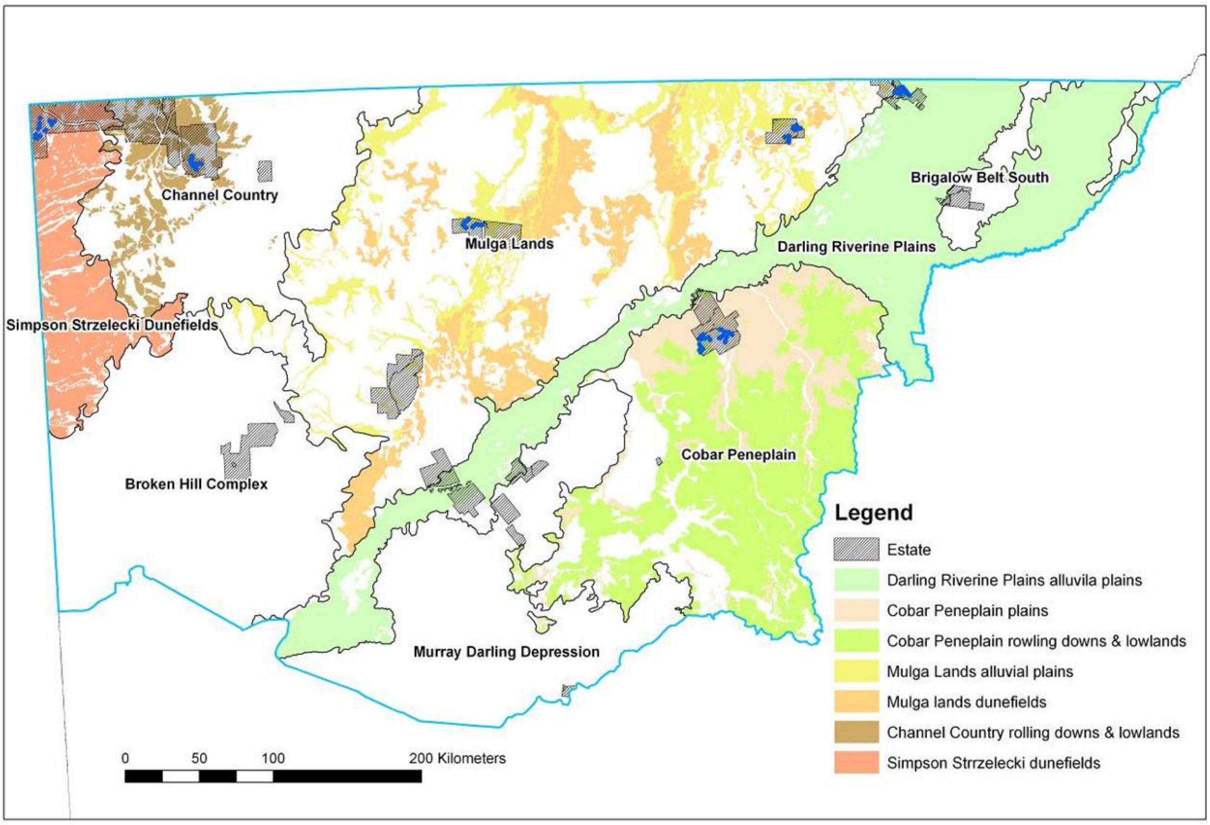

Figure A6-2: Strata sampled in the trial. A cluster of 16 sites was established on conservation reserves within seven of the larger strata only

Ground-dwelling species were censused at each site using a combination of live trapping, timed diurnal and nocturnal searches and incidental observations. Each site consisted of six pitfall traps and two pairs of funnel traps spaced at 20 m intervals (Figure A6-3). Pitfall traps were constructed from PVC stormwater pipe (16 cm diameter, 60 cm high) buried vertically into the ground with the top flush to the surface. Drift fences made from 30 cm fibreglass flywire were buried 5–10 cm into the ground. Drift fences extended five metres either side of the traps, and were positioned to minimise disturbance to vegetation. Drift fences were used to improve trap efficiency by guiding animals into the pitfalls. The location of each pitfall trap was recorded on GPS and marked with a fence dropper. Each trap was fitted with heavy metal lid to prevent animals being caught when the traps were not in use.

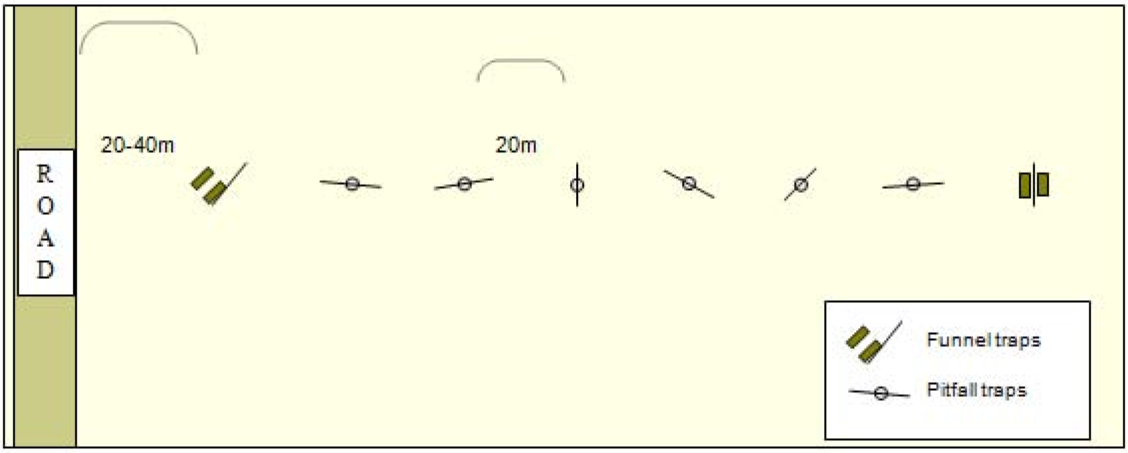

Figure A6-3: The configuration of traps at each site

Funnel traps was placed at either end of the line of pitfall traps. Traps were placed in pairs with a 10 m drift fence running between them (Figure A6-4). The bottom of the drift fence was buried into the earth to prevent fauna from going underneath. A length of reflective sarking was placed over each funnel trap to provide shade for trapped animals. Funnel traps may be particularly useful for sampling fauna that may be under-sampled in pitfall traps, such as arboreal geckoes and medium to large-sized reptiles (Thompson & Thompson 2007).

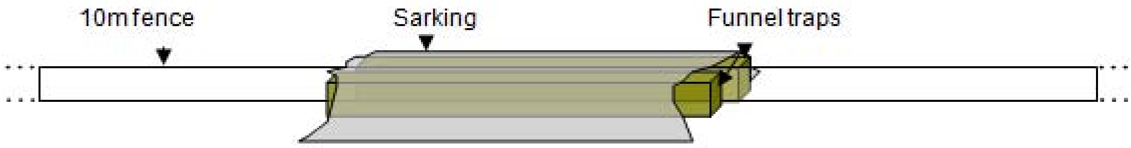

Figure A6-4: Funnel traps were set in pairs around a shared drift fence

Traps were opened for four consecutive days in between March and April 2009. Traps were checked in early morning and late afternoon. Trapped animals were identified, sexed and marked temporarily so that within-survey recaptures could be identified.

Timed diurnal and nocturnal searches were conducted immediately adjacent to each site at various times of the day and night, concurrent with the trapping. Each search was for 10 minutes. Incidental observations during the time spent at each site (eg while opening, closing and checking traps) were also recorded. Incidental observations may be comparable between sites and times as approximately the same amount of time was spent at each site.

Microbats were censused at one in every four sites for one night only using Anabat. Harp trapping was undertaken to collect reference calls of microbats as required.

The following attributes were recorded for each site, as defined by an area of approximately one hectare surrounding the third pitfall trap:

- Location
- Broad vegetation category according to the structural formation classes listed in Walker & Hopkins (1998)
- Disturbance history
- Broad soil type

- % cover of ground layer elements
- Leaf litter description
- Presence and relative abundance of habitat trees (dead stags) and logs
- % cover of each vegetation strata present and the heights and identification of the dominant species in each strata
- Topographic characteristics
- Stream or waterbody characteristics (if present).

The intent of this monitoring regime was to assess species presence at many sites rather than measure abundance precisely at a few sites on the assumption that site occupancy would fluctuate less and hence provide a more powerful measure of trend. This is particularly relevant in arid areas, where the abundance of many species may vary significantly in response to rainfall (eg Dickman et al. 1999a, 1999b).

Results

Ten species of amphibians, 13 species of ground-dwelling mammals and 51 species of reptiles were detected across 112 sites (Table A6-2). Of these, 15 species were detected at 11 (10 per cent) or more sites. Thirty-six species (49 per cent) were detected on one stratum only. While trapping was particularly efficient for detecting mammals, time searches and incidental observations detected many amphibian and reptile species at sites where they were not trapped. Thus while variation in detection between observers was apparent for timed searches and incidental records, these data may contribute to monitoring as they may improve detection probabilities for many species significantly. Data for microbats are not yet analysed.

Discussion

As with the trial program for potoroo, site occupancy could be used to measure long-term trends in distribution for each species. However, a significant number of additional sites would be required to increase the representativeness of sampling and the power to detect trends. A grid could be used not to locate sites systematically, but to ensure that clusters of sites are dispersed across target strata. In the short term, it may be productive to focus on the strata already sampled, as relatively few additional sites may be required to sample species that appear to occur only within these strata (eg *Notomys fuscus* in Simpson Strzelecki dunefields). The number of strata targeted could be expanded over time as resources permit. Detection probabilities could be estimated for each species from the trapping, timed search and incidental data to assess and improve the reliability of the current monitoring regime for determining site occupancy (cf. Appendix 5).

Table A6-2: The number of sites in which each species was detected by trapping and, in brackets, the number of additional sites in which each species was detected via timed searches or incidental observation

Scientific name	Common name	Channel Country Rolling downs & lowlands Sturt NP	Cobar Peneplain Rolling downs & lowlands Gundabooka NP	Cobar Peneplain Plains Gundabooka NP	Darling Riverine Alluvial plains Culgoa NP	Mulga Lands Dunefields Ledknapper NP	Mulga Lands Alluvial plains Nocoleche NP	Simpson Strzelecki Dunefields Sturt NP
Amphibians								
Crinia deserticola	Desert froglet	0 (0)	0 (0)	0 (0)	0 (+1)	0 (0)	0 (0)	0 (0)
Cyclorana novaehollandiae	New Holland Frog	0 (0)	0 (0)	0 (0)	1 (+1)	0 (0)	0 (0)	0 (0)
Cyclorana platycephala	Water-holding frog	0 (0)	0 (+1)	0 (0)	0 (+1)	0 (0)	0 (0)	0 (0)
Limnodynastes fletcheri	Long-thumbed Frog	0 (0)	0 (0)	0 (0)	1 (+1)	0 (0)	0 (0)	0 (0)
Limnodynastes ornatus	Ornate Burrowing Frog	0 (0)	2 (0)	0 (0)	1 (+1)	0 (0)	0 (0)	0 (0)
Limnodynastes salmini	Salmon Striped Frog	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)
Litoria peronii	Peron's Tree Frog	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)
Litoria rubella	Desert Tree Frog	0 (0)	2 (+1)	0 (0)	1 (+1)	0 (0)	0 (0)	0 (0)
Notaden bennettii	Crucifix Frog	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uperoleia rugosa	Wrinkled Toadlet	0 (0)	0 (0)	0 (+1)	0 (0)	0 (0)	0 (0)	0 (0)

Scientific name	Common name	Channel Country Rolling downs & lowlands Sturt NP	Cobar Peneplain Rolling downs & lowlands Gundabooka NP	Cobar Peneplain Plains Gundabooka NP	Darling Riverine Alluvial plains Culgoa NP	Mulga Lands Dunefields Ledknapper NP	Mulga Lands Alluvial plains Nocoleche NP	Simpson Strzelecki Dunefields Sturt NP
Mammals								
Antechinomys laniger	Kultarr	0 (0)	1 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Leggadina forresti	Forrest's mouse	2 (0)	0 (0)	0 (0)	2 (0)	1 (0)	0 (0)	0 (0)
Macropus fuliginosus	Western grey kangaroo	0 (0)	0 (0)	0 (+1)	0 (+1)	0 (+8)	0 (0)	0 (+2)
Macropus giganteus	Eastern grey kangaroo	0 (0)	0 (0)	0 (+2)	0 (+1)	0 (0)	0 (0)	0 (0)
Macropus rufus	Red kangaroo	0 (+16)	0 (0)	0 (0)	0 (+8)	0 (0)	0 (+14)	0 (+16)
Notomys fuscus	Dusky hopping-mouse	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	5 (0)
Planigale gilesi	Paucident Planigale	2 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Planigale tenuirostris	Narrow-nosed Planigale	2 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Pseudomys hermannsbergensis	Sandy inland mouse	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	4 (0)
Sminthopsis crassicaudata	Fat-tailed dunnart	5 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	3 (+3)
Sminthopsis macroura	Stripe-faced dunnart	3 (+1)	0 (0)	0 (0)	13 (0)	2 (0)	2 (0)	5 (0)

Scientific name	Common name	Channel Country Rolling downs & lowlands Sturt NP	Cobar Peneplain Rolling downs & lowlands Gundabooka NP	Cobar Peneplain Plains Gundabooka NP	Darling Riverine Alluvial plains Culgoa NP	Mulga Lands Dunefields Ledknapper NP	Mulga Lands Alluvial plains Nocoleche NP	Simpson Strzelecki Dunefields Sturt NP
Sminthopsis murina	Common dunnart	0 (0)	2 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Tachyglossus aculeatus	Short-beaked echidna	0 (0)	0 (+1)	0 (0)	0 (+1)	0 (+5)	0 (+3)	0 (+2)
Reptiles								
Amphibolurus nobbi coggeri		0 (0)	0 (0)	0 (0)	1 (+2)	4 (0)	0 (0)	0 (0)
Cryptoblepharus carnabyi	Spiny-palmed Shinning-skink	0 (0)	0 (+2)	0 (+5)	0 (0)	0 (0)	0 (+1)	0 (+2)
Cryptoblepharus plagiocephalus	Callose-palmed shinning-skink	0 (0)	0 (0)	0 (0)	0 (+1)	0 (0)	0 (0)	0 (0)
Ctenophorus fordi	Mallee military dragon	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (0)
Ctenophorus nuchalis	Central netted dragon	1 (0)	3 (0)	5 (+2)	0 (0)	0 (0)	1 (0)	9 (0)
Ctenophorus pictus	Painted dragon	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (+2)	8 (+4)
Ctenotus allotropis	Brown-blazed wedgesnout ctenotus	0 (0)	0 (0)	0 (+1)	0 (0)	0 (0)	0 (0)	0 (0)
Ctenotus brachyonyx	Short-clawed ctenotus	0 (0)	0 (0)	0 (0)	0 (0)	1 (+1)	0 (0)	0 (0)

Scientific name	Common name	Channel Country Rolling downs & lowlands Sturt NP	Cobar Peneplain Rolling downs & lowlands Gundabooka NP	Cobar Peneplain Plains Gundabooka NP	Darling Riverine Alluvial plains Culgoa NP	Mulga Lands Dunefields Ledknapper NP	Mulga Lands Alluvial plains Nocoleche NP	Simpson Strzelecki Dunefields Sturt NP
Ctenotus brooksi taeniatus		0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (+1)
Ctenotus regius	Pale-rumped ctenotus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (+3)	1 (+3)
Ctenotus robustus	Robust ctenotus	0 (0)	0 (0)	2 (0)	1 (0)	1 (0)	0 (0)	0 (0)
Ctenotus schomburgkii	Barred wedgesnout ctenotus	0 (0)	0 (0)	0 (0)	0 (0)	4 (+5)	12 (0)	14 (0)
Demansia psammophis	Yellow-faced whip snake	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Diplodactylus byrnei	Gibber gecko	0 (+1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)
Diplodactylus conspicillatus	Fat-tailed diplodactylus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (0)	0 (0)
Diplodactylus steindachneri	Box-patterned gecko	0 (0)	0 (0)	0 (0)	1 (+1)	0 (0)	0 (0)	0 (0)
Diplodactylus stenodactylus	Crowned gecko	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (+2)
Diplodactylus tessellatus	Tessellated gecko	0 (+2)	0 (0)	0 (0)	4 (+2)	0 (0)	0 (0)	0 (0)

Scientific name	Common name	Channel Country Rolling downs & lowlands Sturt NP	Cobar Peneplain Rolling downs & lowlands Gundabooka NP	Cobar Peneplain Plains Gundabooka NP	Darling Riverine Alluvial plains Culgoa NP	Mulga Lands Dunefields Ledknapper NP	Mulga Lands Alluvial plains Nocoleche NP	Simpson Strzelecki Dunefields Sturt NP
Diplodactylus vittatus	Wood gecko	0 (0)	0 (+1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Egernia inornata	Desert skink	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	4 (0)	0 (0)
Egernia striolata	Tree skink	0 (0)	0 (0)	0 (0)	3 (+5)	0 (0)	0 (0)	0 (0)
Eremiascincus fasciolatus	Narrow-banded sand-swimmer	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (0)
Furina diadema	Red-naped snake	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)
Gehyra variegate	Tree dtella	0 (0)	0 (+4)	0 (+5)	2 (+1)	0 (0)	0 (+4)	0 (+7)
Heteronotia binoei	Bynoe's gecko	0 (0)	0 (+3)	1 (0)	2 (+2)	1 (+1)	0 (0)	0 (0)
Lerista labialis	Southern sandslider	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	6 (+2)
Lerista muelleri	Wood mulch-slider	0 (0)	0 (+3)	0 (+2)	0 (0)	1 (+1)	0 (+4)	0 (0)
Lerista rhodonoides		0 (0)	0 (+1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lialis burtonis	Burton's snake-lizard	0 (0)	1 (0)	0 (0)	0 (0)	1 (+1)	0 (0)	0 (0)
Lophognathus burnsi	Burns' dragon	0 (0)	0 (0)	0 (0)	7 (+2)	0 (0)	0 (0)	0 (0)
Lucasium damaeum	Beaded gecko	0 (0)	0 (0)	0 (0)	0 (0)	2 (0)	0 (0)	0 (0)

Scientific name	Common name	Channel Country Rolling downs & lowlands Sturt NP	Cobar Peneplain Rolling downs & lowlands Gundabooka NP	Cobar Peneplain Plains Gundabooka NP	Darling Riverine Alluvial plains Culgoa NP	Mulga Lands Dunefields Ledknapper NP	Mulga Lands Alluvial plains Nocoleche NP	Simpson Strzelecki Dunefields Sturt NP
Menetia greyii	Common dwarf skink	0 (0)	0 (+1)	0 (+5)	3 (0)	0 (+1)	0 (+3)	1 (+2)
Morethia boulengeri	South-eastern morethia skink	0 (0)	1 (+4)	0 (+4)	8 (+4)	0 (0)	2 (+4)	0 (0)
Nephrurus levis	Three-lined knob-tail gecko	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (0)	1 (+1)
Oedura marmorata	Marbled velvet gecko	0 (0)	0 (+2)	0 (+1)	1 (0)	0 (0)	0 (0)	0 (0)
Parasuta dwyeri	Dwyer's snake	0 (0)	1 (0)	0 (+1)	0 (0)	2 (0)	0 (0)	0 (0)
Pogona barbata	Bearded dragon	0 (0)	0 (0)	0 (0)	4 (+4)	0 (0)	0 (0)	0 (0)
Pogona vitticeps	Central bearded dragon	1 (+2)	0 (+4)	2 (+4)	0 (0)	0 (+3)	2 (+2)	3 (0)
Proablepharus kinghorni	Red-tailed soil-crevice skink	0 (0)	0 (0)	0 (0)	3 (0)	0 (0)	0 (0)	0 (0)
Pseudechis australis	King brown snake	0 (0)	0 (0)	0 (+1)	0 (0)	0 (0)	0 (0)	0 (+2)
Pseudonaja textilis	Eastern brown snake	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)
Rhynchoedura ornata	Beaked gecko	0 (0)	0 (+1)	0 (+3)	0 (0)	0 (0)	7 (0)	1 (0)

Scientific name	Common name	Channel Country Rolling downs & lowlands Sturt NP	Cobar Peneplain Rolling downs & lowlands Gundabooka NP	Cobar Peneplain Plains Gundabooka NP	Darling Riverine Alluvial plains Culgoa NP	Mulga Lands Dunefields Ledknapper NP	Mulga Lands Alluvial plains Nocoleche NP	Simpson Strzelecki Dunefields Sturt NP
Simoselaps fasciolatus	Narrow-banded snake	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (+2)
Strophurus ciliaris	Spiny-tailed gecko	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (+6)
Strophurus intermedius	Southern spiny-tailed gecko	0 (0)	0 (0)	0 (+2)	0 (0)	0 (0)	0 (0)	0 (0)
Suta suta	Curl snake	1 (+2)	0 (0)	0 (0)	4 (0)	0 (0)	0 (0)	0 (+1)
Tiliqua rugosa	Shingle-back	0 (0)	0 (+1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (+2)
Tympanocryptis tetraporophora	Eyrean earless dragon	1 (+4)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Varanus gouldii	Gould's goanna	0 (0)	0 (+1)	0 (+2)	0 (0)	1 (+7)	1 (+7)	0 (+9)
Varanus tristis	Black-headed monitor	0 (0)	1 (0)	0 (0)	1 (+3)	0 (0)	0 (0)	0 (0)
Varanus varius	Lace monitor	0 (0)	0 (0)	0 (+1)	0 (+1)	0 (0)	0 (0)	0 (0)

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Appendix 7: Species richness derived from Atlas data

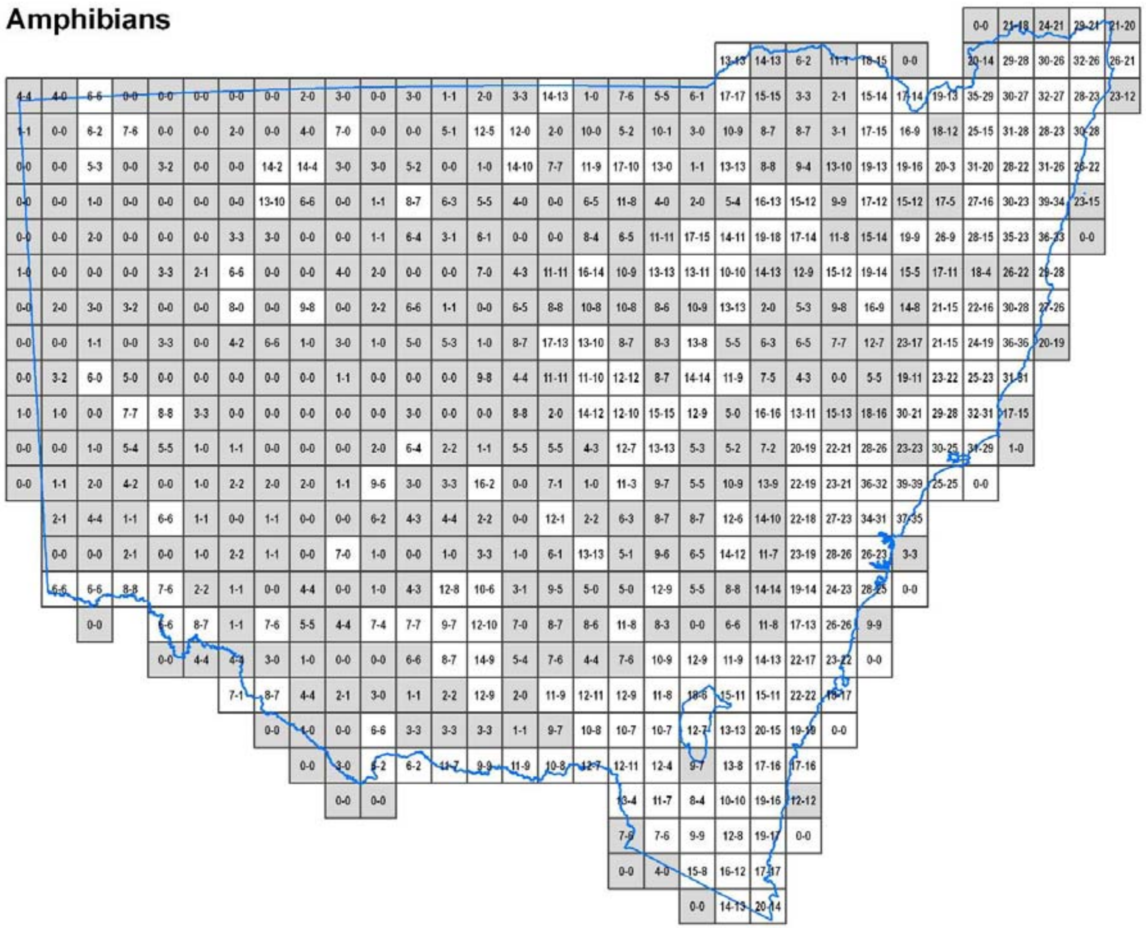

Figure A7-1: Amphibian species richness estimated from all records (1st number) and from records since 1 January 1996 (2nd number) for a 40 km x 40 km grid partitioning of NSW

Note: Doubtful species were removed by expert review. Shaded cells were assessed to have inadequate inventories likely reflecting insufficient survey.

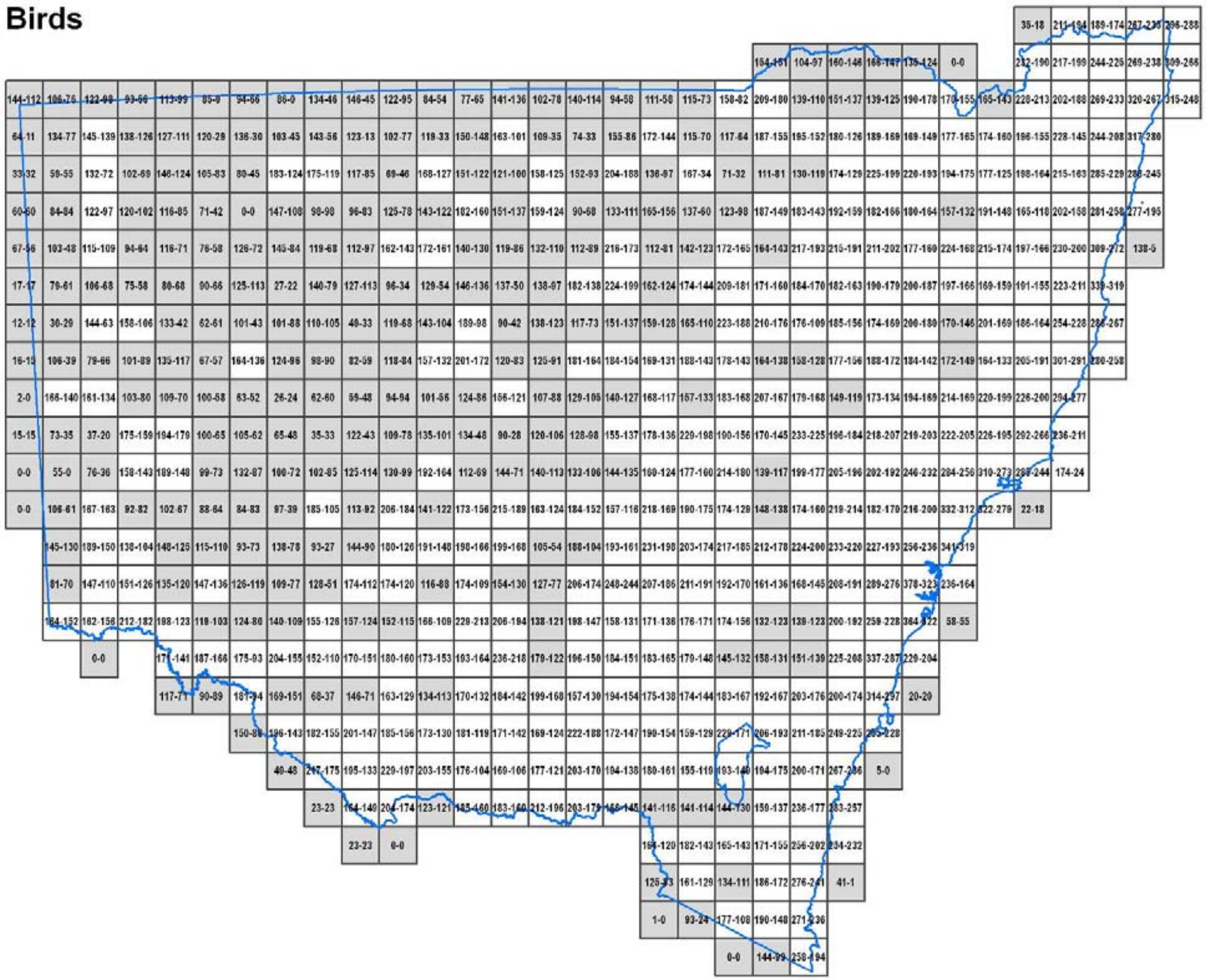

Figure A7-2: Bird species richness estimated from all records (1st number) and from records since 1 January 1996 (2nd number) for a 40 km x 40 km grid partitioning of NSW

Note: Doubtful species were removed by expert review. Shaded cells were assessed to have inadequate inventories likely reflecting insufficient survey.

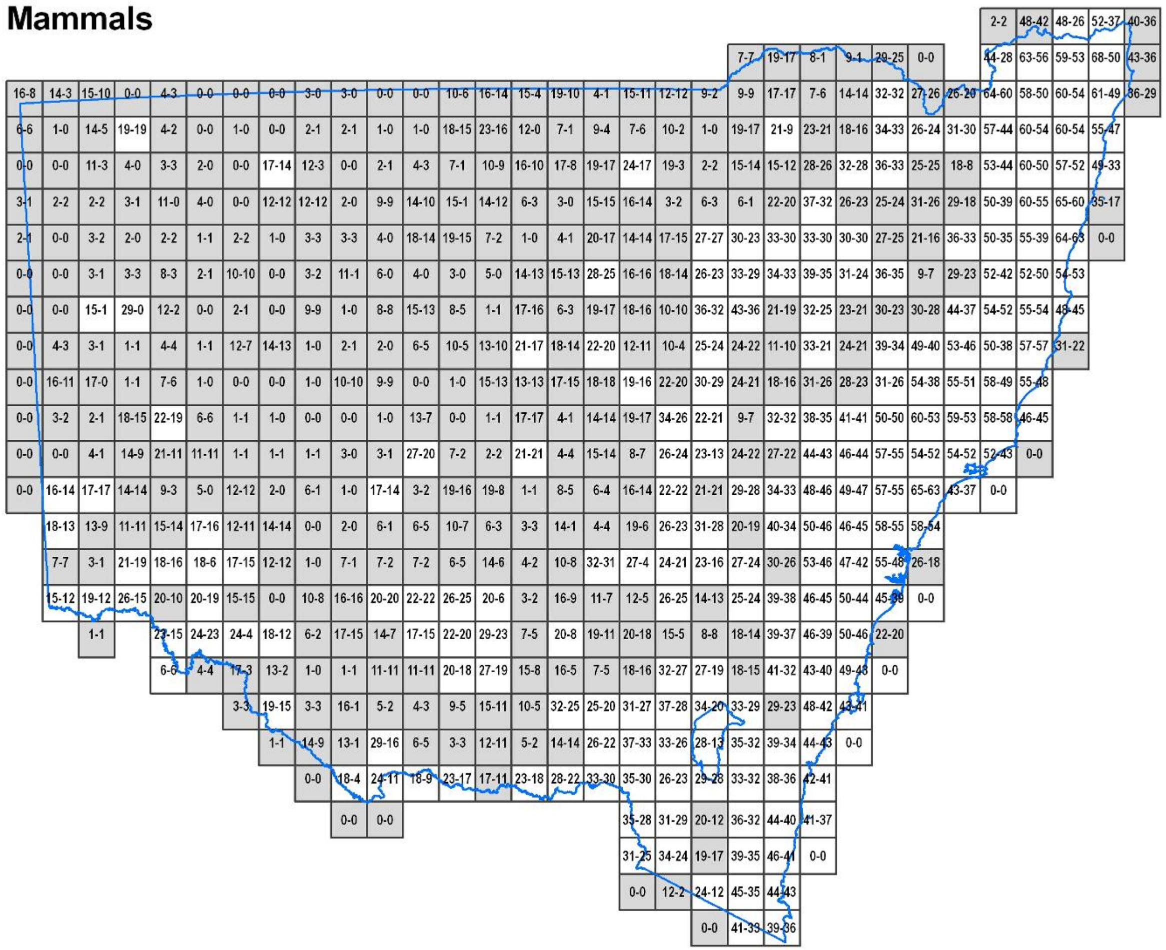

Figure A7-3: Mammal species richness estimated from all records (1st number) and from records since 1 January 1996 (2nd number) for a 40 km x 40 km grid partitioning of NSW

Note: Doubtful species were removed by expert review. Shaded cells were assessed to have inadequate inventories likely reflecting insufficient survey.

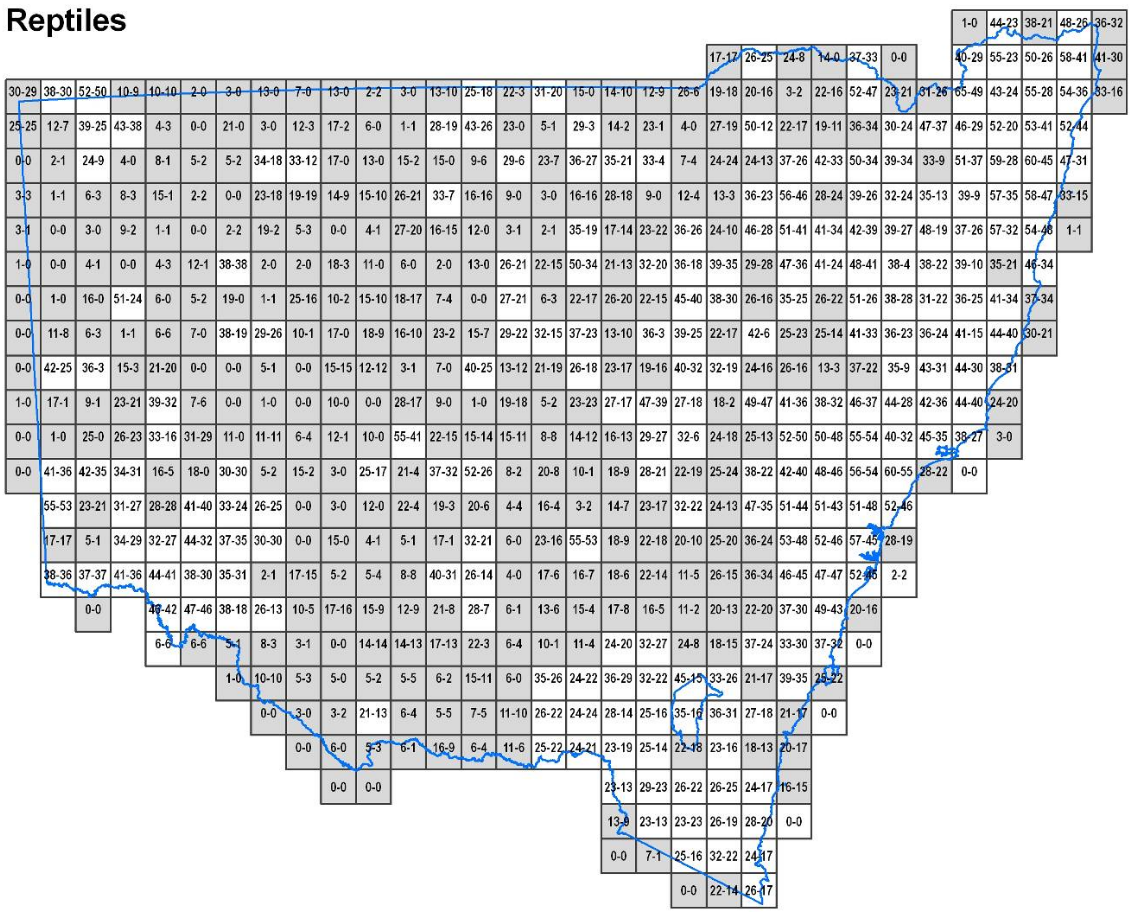

Figure A7-4: Reptile species richness estimated from all records (1st number) and from records since 1 January 1996 (2nd number) for a 40 km x 40 km grid partitioning of NSW

Note: Doubtful species were removed by expert review. Shaded cells were assessed to have inadequate inventories likely reflecting insufficient survey.

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