Milestone 2: Gap Analysis of monitoring and associated data, and an update on data collation

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A report to the Mallee CMA and multi-regional "National Malleefowl Monitoring, Population Assessment and Conservation Action Project" steering committee.

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Introduction

The multi regional "National Malleefowl Monitoring, Population Assessment and Conservation Action Project" is a two year NHT funded project that implements key components of the National Malleefowl Recovery Plan. The general objects of the project are:

- Collate existing Malleefowl monitoring data for analysis
- Interpret breeding density trends in the light of management practises and environmental variables
- Develop a consistent national monitoring system and a national database, and foster on-going and self-sufficient monitoring that facilitates government, private and community monitoring programs.
- Develop the monitoring program in the future so that management actions that are most beneficial to Malleefowl conservation can be identified and demonstrated, and integrate this knowledge into outcomes for conservation on private and public land across Australia.
- Involve all stakeholders in this project and provide advice to regional NRM bodies on how best to promote Malleefowl conservation within their region.

The first phase of the project aims to tackle the first two points above. This document reports on the first of the above points and specifically deals with information gaps that are apparent following the collation of the national monitoring data.

'Gap analysis' is a term used to describe the identification and remedy (where possible) of gaps between expected or desired levels and the actual levels of some entity. The gap analysis in this report examines the gap between the data we have available for the review and analysis of Malleefowl monitoring data, and the data we expected or would reasonably have liked to have for these analyses. While some gaps thus identified may be remedied if a reliable source of data can be found, other gaps may be by nature unfillable (ie. data that was not collected).

Every effort has been made to represent data accurately. If you notice an error, or feel something has been misrepresented, please notify the author.

Statement of objectives

1. Analysis of Trends in Malleefowl populations in regard to environmental factors

Analysis will concentrate on explaining the variation in breeding densities from year to year and from site to site. The central question it will address is:

- *Are Malleefowl populations declining, and if so, what environmental factors might be responsible?*

The breeding density of Malleefowl at each of the monitoring sites provides a useful indicator of general population trends. Breeding density is subject to short term fluctuations in response to climate, especially drought, but in most years provides an good indication of population size and the reproductive output for a given patch of habitat.

This analysis requires accurate records of breeding densities (breeding numbers per unit area) and associated environmental variables at each site over a number of years.

2. Effectiveness of monitoring data in terms of producing useful data

Analysis will concentrate on examining the effectiveness of the current monitoring data protocols:

- *Is the monitoring program delivering the information that is needed for conservation, and how can it be improved?*

Protocols for monitoring Malleefowl were developed in the early 1990s in Victoria and were adopted in SA. These protocols took the form of a datasheet and database and are the basis of current protocols including the Cyberracker system now used in most states. The usefulness of these data has not previously been examined, but is in need of review. Evaluating the usefulness of the nest descriptions and other data requires that these data have been consistently collected over a number of years.

Data standards and identification of data gaps

Table 1 shows the data standards that are required for the analysis of trends and data effectiveness. These standards form a basis from which to examine gaps between the data we have available for the review and analysis of Malleefowl monitoring data, and the data we expected or would like to have for these analyses.

Table 1. Desirable data standards and how they relate to the analysis of Malleefowl population trends and the review of the effectiveness of the monitoring. Importance is rated as essential, desirable (✳✳ highly desirable; ✳ desirable), or unnecessary (blank).

SUMMARY TABLE	Trend analysis	Monitoring effectiveness
Internal to monitoring protocols		
1. Accurate records of nests used for breeding	Essential	✳✳
2. Nest description data	✳✳	Essential
3. Consistency in study sites	Essential	✳
4. Monitoring site locations	✳✳	✳
5. Several years of data	Essential	Essential
6. Annual monitoring	✳	✳✳
7. All nests usually checked within areas	✳✳	✳
8. Regular re-searching of sites	✳✳	✳✳
9. Fox and other species abundance data (internal)	✳✳	✳✳
Information external to monitoring protocols		
10. Information on fox abundance and control near monitoring grids	✳✳✳	
11. Information on major herbivore changes or control	✳	
12. Information on landscape context	✳✳	
13. Information on climate	✳✳✳	
14. Information on fire history	✳✳	
15. Information on food pulses	✳	
16. Environmental GIS attributes (soil, habitat, veg classes)	✳	

Available data and analysis of gaps

1. Accurate records of nests used for breeding

How accurately the monitoring data represents the breeding status of each nest visited is difficult to determine retrospectively unless associated data or photos are routinely collected. In NSW, corroborating data is not collected but there is reason to believe the data is accurate as a few experienced staff have collected the data over many years. Elsewhere, a diversity people, largely volunteers, have largely collected the monitoring data and the question of accuracy is of greater concern. In Vic all volunteers have routinely been trained and consistency in assessing the activity status of mounds is high, at least from 1994 onwards. In SA and WA the degree of training has varied and may have been minimal in some cases.

Consistent training is important both to enable people to interpret signs of breeding activity, and to correctly interpret the meaning the data categories that appear on the data sheets. The most important data definition regards the meaning of 'active' (ie. currently used as an incubator), and I am not aware of evidence of systematic errors that would invalidate these data. Errors do occur, and there are cases in which volunteers in SA, Vic and WA appear to have misinterpreted the meaning of 'active', but these instances appear isolated rather than systemic. Such cases can be often detected where there is corroborating data.

Another aspect of accuracy in determining the activity of nests is the date on which nests are visited. Malleefowl nests are most reliably monitored for breeding from October to January; before and after this period determining the activity status of a nest becomes increasingly difficult and ambiguous. For example, there are a number of mounds that have were monitored in autumn and recorded as active but for which other data exists which indicates were being prepared for the following season rather than the season in which activity was recorded.

Poorly recorded or illegible data has also led to uncertainty in some instances. This problem was not uncommon in data from the early 1990s from Vic (Benshemesh 1997), and is also apparent in some data sets from SA and WA. This problem is generally not visible once the data have been entered, but may explain why the activity field of some database records is blank even though the nests were apparently visited. Poorly recorded or illegible data may also explain why data that has been interpreted more than once is sometimes in disagreement. An extreme example of this exists for the data from Cooltong (SA) where 36 nest were visited in 1993 and the results were entered onto databases twice. While one version recorded 17 active nests, the other recorded 14, but in terms of individual nests only five nests were considered active in both versions; this degree of concordance is no better than chance.

While these examples are of concern, most of the data appears accurate and that the inconsistencies that exist are not so great as to invalidate analysis of trends except in rare cases.

SUMMARY	NSW	SA	Vic	WA
1. Accurate records of nests used for breeding	Yes	Yes (mostly)	Yes	Unclear*

(* lack of corroborating data, see below)

Gap 1. Errors or uncertainty in activity

Remedy: Further checking of nest activity status in both SA and WA records will improve data quality, although this will only be possible where corroborating data has been recorded (ie. nest features, notes, etc). Records will also be screened in regard to dates. New database fields have been created to indicate whether there is substantial doubt about the original activity determination of a nest, and whether each nest is regarded as active in this project. The original data will not be altered.

2. Nest description data

Nest descriptions have two uses: firstly they provide information that can be used to corroborate activity determinations and enable vetting of data; and secondly these descriptions provide the material to assess the effectiveness of the monitoring.

In NSW, additional data is not collected as part of the monitoring program but the data are likely to be of a high standard as only a few experienced staff check the 255 nests at Tarawi and Mallee Cliffs each year.

In contrast to NSW, monitoring in most other areas is done by a large number of volunteers. Maintaining data collection standards is consequently much more difficult and there is a much greater need to vet records to ensure that nests are correctly characterised as being used for breeding or not. To this end, in both SA and Vic the original datasheet protocols developed in the early 1990s have been consistently used to date and provide a means of validating or at least corroborating activity determinations. Three nest features that are useful for corroborating activity at a nest are the presence/absence of a crust on the nest, whether a nest has been recently scraped, and the nest shape. In SA, a total of 5,347 nests have been recorded on the database as found and monitored since 1989, and 54%, 72% and 58% of these have data on crust, scraped and profile respectively. These figures may increase as more of the original datasheets are located: about 22% of SA records currently exist only as summaries of nest activity (active/inactive) compiled from secondary sources (reports, file notes) rather than the original datasheets which appear to have been misplaced.

In Vic, a total of 10,397 nests have been recorded on the database as found and monitored since 1989, and 94%, 97% and 98% have data on crust, scraped and profile respectively.

In WA, the MPG and NCMPG developed their own brief data sheets and only the presence of certain features was recorded, if at all. The MPG generally sketched/recorded the mound shape, and often provided written observations, but otherwise nest features do not appear to have been routinely recorded. These data are of limited use for vetting. Records from WA over the past year or two have provided full nest descriptions, as in SA and Vic.

SUMMARY	NSW	SA	Vic	WA
2a. Ability to validate/vet	No	Mostly (54-72% of data)	Yes (94-98% of data)	Variable
2b. Data suitable for examining effectiveness of monitoring protocols	No	Variable	Yes	No

Gap 2a.Insufficient data to vet many records from SA and WA for trend analysis.

Remedy 2a: None. A substantial portion of records in all states (except Vic) cannot be vetted and must either be accepted on faith, or rejected.

Gap 2b.Incomplete data sets for examining the effectiveness of monitoring protocols in all areas except Vic.

Remedy 2b: A large and virtually complete data set on nest features exists from Vic, and it is proposed that the examination of the effectiveness of monitoring be confined to this data set. Geographic representation is not an issue for this analysis.

3. Consistency in study sites

To determine the trends in breeding populations, there must be some control over sampling effort. In most cases a standard area is used to sample the population, although in some cases a standard number of known nests are monitored instead. It is essential that these standards be maintained over the years if accurate trends are to be determined.

In Vic, SA and WA, all nests in standard areas or 'grids' are visited most years, although how well these areas are defined varies. Including active nests that are outside the standard area may greatly distort actual population trends. In Vic, these areas are sharply defined and every nest in the database is identified in relation to the standard (the 'common set'). In SA, most sites seem to have been pegged, but the precise coordinates of grid corners is less certain (a legacy of the past when GPS was less accurate). This means it is difficult to know whether a new nest should be included in comparisons, or whether it is outside the standard. This is an especially important for SA because sites/grids were routinely searched and there were many opportunities for including more nests at the edges and for the sites to incrementally expand. DEH SA is currently re-examining the boundaries so that precise standards for comparison can be applied. In WA, coordinates of grid corners and boundaries are usually not available, although most sites are marked on the ground with posts and markers along grid-lines. In some cases the locations of nests are not available either.

At Mallee Cliffs, Mylatchie and Tarawi in NSW, a standard set of known and marked nests over a large area is visited each year by helicopter (active nests are also visited on foot). The monitoring data from SW NSW is collected by a small group of experienced rangers and is likely to be consistent and reliable. These data show the proportion of nests active each year, rather than breeding density, and do not account for new nests that are made by the birds. How accurately these data reflect the trends in breeding populations depends on the rate at which newly made Malleefowl nests replace old ones.

SUMMARY	NSW	SA	Vic	WA
3. Standard areas for comparison across time	Yes	Mostly	Yes	No

Gap 3a: Lack of areal standards

Remedy 3a: DEH SA is currently examining the original grid boundaries and deriving these coordinates so that areal standards can be precisely defined. All monitored nests will then be examined in relation to these standards and nests that are outside these areas will be omitted from trend analyses. In both SA and WA, if previously defined

standards are not available, be standards will be created for this analysis (ie, the maximum area that is common to all monitoring efforts).

Gap 3b: Poor understanding of how accurately measures of the proportion of nests active each year reflects the breeding population density.

Remedy 3b: The rate at which newly made Malleefowl nests replace old nests will be estimated from repeat searches of monitoring sites in other areas under similar conditions.

4. Monitoring site locations

Information of the geographic location of each grid is important so that spatial environmental data describing the site can be determined. These data include landscape values, rainfall, vegetation type, soil type, fire history, and other types of information that is stored or produced spatially.

In some cases in the location of monitoring sites has not been adequately described, although in all cases monitoring groups have been willing to provide these data.

SUMMARY	NSW	SA	Vic	WA
4. Monitoring site locations	Yes	Yes	Yes	Mostly

Gap 4: Uncertain geographic location of some monitoring sites.

Remedy: We will continue to work with groups to determine the precise location of all sites (all but a few sites have been determined).

5. Several years of data from each monitoring site

In order to determine trends, or to measure changes in nests in time, several samples are requires across time. Of the 96 sites for which data has been collated, about 50 have three or more years of data, the remainder (46) being sites that have only recently been established or sites that have infrequently been monitored.

SUMMARY	NSW	SA	Vic	WA
5. Several years of data from each monitoring site	Yes	Mostly	Yes	Some

Gap 5: Not all sites have been monitored enough times to show changes in breeding numbers or nest features.

Remedy 5: None. Sites with at least three years data will be given priority in used in the analysis of trends and the effectiveness of monitoring. About 25 sites have been monitored only twice and most of these occurred in the last two years and are of limited interest. However, there are six sites in SA that were first monitored in 2001 and again in 2005 and these might may also be included in the trend analyses. A list of sites with the number of seasons of data is shown in Appendix 2.

6. Annual monitoring

Annual monitoring of the breeding population at a site is desirable for a number of reasons and provides important data for both trend and effectiveness analyses. Firstly, each season monitored provides an estimate of breeding density in relation to seasonal environmental condition and provides the data from which to determine trends. Secondly, annual monitoring provides detailed data on how nests change in time, and this provides important information to evaluate monitoring effectiveness. For

example, the rate at which nests change can only be measured if the last year in which a nest was active is known, and this requires an annual inspection.

For those monitoring sites visited at least three times in NSW and Vic, every site is usually monitored every year and exceptions are rare; established grids were monitored in 92-93% of seasons (ie. one season missed per 12-13 seasons monitored). In SA and southern WA, monitoring sites that were visited at least three times were visited 76-79% of seasons respectively (ie. one season missed per three to four seasons monitored).

Table 2. Proportion of seasons in which sites were monitored (only includes sites that were monitored at least 3 seasons). Sites were considered monitored if at least one nest was monitored.

	NSW	SA	VIC	WA*
Grid-Seasons Monitored	92% (24)	76% (152)	93% (291)	79% (23)
Grid-Seasons missed	8% (2)	24% (49)	7% (23)	21% (6)
Total Grid-Seasons	26	201	312	29
No. Sites	2	19	24	3

* MPG only, NCMPG have another 2 useable grids but these data are still being sorted out.

SUMMARY	NSW	SA	Vic	WA
6. Annual monitoring	Yes	Mostly	Yes	Some

Gap 6: Not all sites have been monitored on a regular basis.

Remedy 6: None. While annual data is desirable, it is not essential for the analysis of Malleefowl population trends. However, the effectiveness of the monitoring data could be more easily examined where there exists a complete record of nests at a site, and for this reason the review of the monitoring data may be best limited to these cases.

7. All nests usually checked within designated areas (proportion known visited when a grid was monitored)

To establish the density or the proportion of nests that are used for breeding in any season, it is important that all nests within the designated area are inspected. However, in some years and at some sites, this has not occurred and the data is more difficult to interpret. In NSW where scattered nests are monitored rather than areas, it seems that virtually every nest has been visited each season in which monitoring occurs. In Vic, the number of nests that were missed is usually low, and is publicised amongst volunteers as a target to minimise. In grids that were monitored at least three times since 1989, about 4% of nests have been missed (1 missed per 26 monitored). For sites that were monitored in SA at least three times, an average of 21% of nests have been missed (1 per 4 nests monitored), although this estimate may in part be due to poor nest identification and renumbering of known nests rather than missed nests. For example, at site 11 (Innes) records show an increasing number of nests that were missed each year, and at the same time a similar number of 'new' nests were added to the monitoring system, so that the actual number of nests that were visited each year is remarkably constant. Innes was re-searched most years, and so it can reasonably be

argued that each search was an independent estimate of the breeding population. The Innes example is not typical and it is more common that nearly all nests within each site in SA whenever the site is monitored.

In the southern WA the completeness of the monitoring at each site each year is variable and on average only two thirds of nests were visited when a site was monitored. Often, only nests known to have been previously active were re-visited. It is not known how well or poorly this sampling strategy estimates breeding density.

Table 3. Proportion of recorded nests for a site that were recorded or missed when a site was monitored (only includes sites that were monitored at least 3 seasons). Sites were considered monitored if at least one nest was monitored.

	NSW	SA	VIC	WA*
% missed nests	<1%	21%	4%	33%
% monitored nests	100%	79%	96%	67%
Total nest-seasons	3,075	5,943	10,631	613
No sites	2	19	24	3

* MPG only, NCMPG have another 2 useable grids but these data are still being sorted out.

SUMMARY	NSW	SA	Vic	WA
7. All nests usually checked within areas	Yes	Variable	Yes	No

Gap 7: In SA and WA, not all nests visited during monitoring, resulting in uncertainty in the actual number nests used for breeding.

Remedy 7: In some cases it may be necessary to omit sites from the trend analysis where the proportion of nests monitored is low. Where sites are routinely searched in the course of monitoring and each search can be taken as an independent estimate of breeding density, the fact that some nests are not inspected each season may not be a major problem. This would appear to be the case for most sites on SA and at least some in WA. Elsewhere, remedies will need to be considered on a case by case basis in light of the severity of the problem, and with appropriate statistical advice. It is possible that more complete and extensive data sets, such as that from Vic, could be used to model the uncertainty arising from different levels of incomplete monitoring, although how people chose which nests to monitor would need to be known.

8. Regular re-searching of sites

Although Malleefowl tend to renovate old nests, they do build new nests occasionally and incorporating these into the monitoring is important in order to determine the breeding density at a site. In SA, until recently most of sites were searched every time monitoring was conducted and new nests were incorporated into the results. In Vic, sites have only occasionally been researched, but the resulting data suggest that new nests are rare (except after fire) and suggest that simply checking every known nest provides a reliable estimate of activity. I have not yet investigated the frequency at which sites have been re-searched in WA. In NSW, the study design of the monitoring does not require re-searching (random aerial survey is now also used in addition to monitoring of known nests, but these data require special treatment and are not included in this project).

SUMMARY	NSW	SA	Vic	WA
8. Regular re-searching of sites	N/a	Yes	Mostly	Mostly

Gap 8a: Incomplete knowledge of the frequency at which grids have been re-searched in WA.

Remedy 8a: Monitoring groups in WA most likely will be able to provide this information.

Gap 8b: Incomplete understanding of the effect of not re-searching each site each year on activity estimates.

Remedy 8b: This question has been examined in Vic in 1996 and in most cases the emergence of new nests was rare, suggesting that accurate activity estimates could be obtained by checking known nests every year rather than needing to re-search every grid, every year. Recent re-searches of many grids provide additional data with which to examine this question, and should be analysed with a view to determining the likely accuracy of activity estimates as a function of time since a site was last re-searched. This is an important question and will be examined as part of the effectiveness of monitoring study.

9. Relative abundance of Foxes and other animals (internal)

The monitoring protocol used in SA and Vic from 1990 onwards included information on the frequency at which fox signs occurred on nests. Foxes are implicated in the decline of Malleefowl, and these data provide a unique insight into the relative abundance of this predator during the course of the monitoring. Observers were requested to explicitly state whether or not fox prints and scats were evident on each mound visited. In grids that were monitored at least three times in SA, the occurrence of fox scats and prints was recorded at 76% (n= 3,560) and 74% (n=3,485) of nests that were visited respectively (these proportions may increase as more data sheets are brought to light). In grids that were monitored at least three times in Vic, presence/absence of fox scats and prints were recorded at 95% (n= 9,904) and 97% (n=10,124) of mounds respectively. In both SA and Vic, these data provide a valuable resource for examining trends in fox abundance.

Similar data were collected in regard to the presence of Malleefowl prints and scats at nests with similar success, and provide additional data on the abundance of Malleefowl.

Signs (prints and scats) of other animals were also routinely recorded, although observers were not required to search for these signs with the same rigour as for foxes and Malleefowl, and only the presence of signs was noted (not its absence). Signs of most animals were less frequently recorded, but may provide insights into the relative abundance of animals such as rabbits, goats, and kangaroos.

SUMMARY	NSW	SA	Vic	WA
9. Fox and other species abundance data available	No	Mostly	Yes	No

Gap 9a: Presence/absence of fox and other animal signs has not been collected at Malleefowl nests in NSW and WA.

Remedy 9a: None. These data can only be examined in the SA and Vic data sets. However, other data on the abundance may be available from other sources (see below)

Gap 9b: Observers vary markedly in their ability to recognise prints and scats. It is not known how this effects relative abundance trends, but there is potential for bias.

Remedy 9b: Variability between observers can be examined as observers are usually recorded for each nest inspection. In regard to trends in time, variability between observers is not a major problem where observers monitor the same nests every year, but may present a bias when personnel change.

10. Fox control intensity and frequency over monitoring period

Fox control is commonly applied in areas in which Malleefowl occur in order to benefit the birds. The monitoring data provide an opportunity to measure the success of these programs in regard to Malleefowl population trends. Indeed, the trend in breeding populations is arguably the best indicator of the success (or otherwise) of these control programs. As foxes are thought to mostly take eggs and chicks, and Malleefowl take several years to mature before they breed (and are visible to the monitoring program), a lag of two to five years is expected between the time fox numbers are reduced and when an effect might be evident in Malleefowl populations.

Baiting using 1080 is considered to be the only effective means of controlling foxes and the effectiveness of a baiting regime is primarily related to four aspects of implementation: frequency (how often baits are laid); intensity (how many baits per area); scale (size of the baited area); and duration (number of years the program is run). These data have been sought for the vicinity of monitoring grids in NSW, SA, Vic and some sites in WA.

Detailed descriptions of baiting regimes have been provided for monitoring sites in SA (by DEH SA) and NSW (by NSW NPWS) that cover the period during which each grid was monitored, in some cases back to the late 1980s. These data generally address the four primary aspects of effective fox control, although some details are still missing at some sites.

In Vic, Parks Victoria have provided data for most sites, but these records mostly only go back a few years. Given the expected lag time between fox control and evidence of an effect on Malleefowl, these data are of limited value in determining the effect of baiting except for the past coupe of years. As Vic has the most complete and detailed monitoring record (accounting for about half the national total) the absence of data on fox control in the 1990s is regrettable. For the most part, fox control does not seem to have been embraced with the same enthusiasm as in other states, but records of what was or was not attempted in the vicinity of monitoring grids would be valuable for the trend analysis.

In WA, some detailed baiting records have been provided by the NCMPG, and these records address the four primary aspects of control effectiveness back to the early 1990s. I have not yet requested information on fox control at other monitoring grids in WA, preferring to first identify the grids that we are likely to use in the analysis.

SUMMARY	NSW	SA	Vic	WA
10. Information on fox abundance and control near monitoring grids over the duration of monitoring	Yes	Yes	No	Some

Gap 10: In Vic there is little or no information on fox baiting at or near monitoring sites before 2000.

Remedy 10: Almost all monitoring grids in Vic are managed by Parks Victoria, and most are in National Parks and Flora and Fauna Reserves. A record of fox baiting in these sites almost certainly exists in some form, but is apparently not accessible. A renewed effort should be made by Parks Victoria, DSE and VMRG to locate these records, or at least obtain anecdotal accounts, of the fox baiting efforts by these departments in the 1990s.

11. Herbivore control

Herbivore control may effect Malleefowl populations in a number of ways such as improving habitat condition, reducing competition, and reducing predator numbers through secondary poisoning. However, these effects are likely to be less pronounced and less immediate, and the results more difficult to quantify and compare, than other factors considered in the analysis. Nonetheless, information of herbivore control works and major changes observed in herbivore would be useful in the analysis of Malleefowl population trends.

Herbivore control might potentially also impact on Malleefowl directly in rare cases. For example, although Malleefowl are known to be highly tolerant to 1080 poison, large doses are nonetheless incapacitating and potentially lethal. There are anecdotal accounts of Malleefowl being found dead after 1080 baiting with oats at Wathe Flora and Fauna reserve in the 1970s, and there may be reason to be a little cautious with this delivery method. Oats is used as the main deliver method for 1080 in rabbit baiting programs in SA, and is currently replacing carrots as a deliver method in Vic.

SUMMARY	NSW	SA	Vic	WA
11. Information on major herbivore changes or control	No	Some	No	No

Gap 11: Knowledge of major changes in herbivore numbers caused by management (ie. extensive culling, poisoning or water closures) and of control works.

Remedy 11. Herbivore control programs operate of various types operate throughout Australia to some degree and at most Malleefowl monitoring sites. Even if information on these programs were readily available, its extent and detail would be unmanageable. Rather, we propose to ask appropriate agencies and managers to identify major changes in herbivore numbers or in their management. Examples of the information we think is achievable and useful include the sudden decline of rabbits after 1996 as a result of the RHD epizootic, local invasions by introduced animals, and control works that produced major changes in herbivore populations.

14. Landscape context

Fragmentation and isolation of habitat are regarded as serious threats not only to Malleefowl, but also to conserving Biodiversity in general. In order to provide simple objective measures of landscape attributes, several values have been measured including: 1) the proportion of cleared habitat within 2km, 5km and 10km of each grid centre; 2) the length of grid edge in common with cleared land; and 3) the size of the patch in which each grid is located. These values have been estimated from GIS coverages for every monitoring site in NSW, SA and Vic. In SA, these estimates were determined by DEH (Sharon Gillam and Roman Urban) and provided to us. I have not yet estimated these values for monitoring grids in NSW and WA.

SUMMARY	NSW	SA	Vic	WA
12. Information on landscape context	No	Yes	Yes	No

Gap 12: Landscape values not yet estimated for monitoring sites in WA that will be used in the analysis.

Remedy 12: Measure landscape values for monitoring sites that will be used in the analysis in NSW and WA. The location of some grids in WA is still unclear, and this information will have to be provided if landscape values are to be determined.

13. Climate

Rainfall is a major determinant of ecological processes in the mallee and information on monthly rainfall over the course of the monitoring is likely to be of great importance in understanding trends in Malleefowl populations. We have purchased monthly rainfall and average daily temperature data from the BoM for the period 1985 to 2005 for every monitoring site in Vic. We have delayed purchase of data for other sites because the location of some sites in WA is still uncertain, and because BoM have been improving their models.

SUMMARY	NSW	SA	Vic	WA
13. Information on climate	No	No	Yes	No

Gap 13: Incomplete rainfall record for most sites outside Vic.

Remedy 13: These data will be purchased once the location is known of all monitoring grids that will be used in the trend analysis.

14. Fire history

Malleefowl breeding populations are sensitive to fire and typically take decades to return to breeding densities that occurred before their habitat was burnt. Thus, the fire history of a site is of great importance in understanding trends that are evident in Malleefowl populations. The scale of fire is also an important attribute, both because in the long-term Malleefowl are likely to take longer to re-inhabit large compared to small burns, and because immediately after a large fire, birds may be displaced and may immigrate into nearby monitoring grids. Other factors, such as fire intensity and frequency, are theoretically also of interest, but these data are rarely available and the pool of monitoring sites burnt in the last few decades too small to justify these refinements.

The fire history of most sites in Vic has been described in terms of 1) the year in which it was last burnt, 2) the proportion of the site that was burnt, and 3) the years in which large fires occurred within 20km of the site. Fire history maps have been provided for SA by DEHSA, and I am currently using these to characterise the fire history of each monitoring site in that state. Elsewhere, fire histories have yet to be provided by state agencies or determined by us.

SUMMARY	NSW	SA	Vic	WA
14. Information on fire history	No	No	Yes	No

Gap 14: Incomplete fire history records for sites in terms of the year sites were last burnt, the proportion burnt, and the occurrence of large fires in the vicinity.

Remedy 14: These data are being prepared for SA sites and have mostly been determined for Vic sites. Elsewhere, these data will need to be provided by state GIS analysts or other sources.

16. Food pulses

While food availability is most likely correlated to rainfall amount and timing, Malleefowl also take advantage of food pulses that are not simply predicted by rainfall, and these may be important in understanding trends in Malleefowl populations. For example, cereal crops are typically planted only every two or three years in mallee areas, but provide supplementary food for Malleefowl in nearby grids even in poor rainfall years. Similarly, lerp outbreaks are not reliably predictable by rainfall, but may provide important food for Malleefowl, especially chicks.

VMRG members have attempted to collect some information on crop rotations in the vicinity of Malleefowl sites in Victoria, but these data do not provide enough information to be useful in trend analyses. This task would be even larger in SA were a higher proportion on monitoring sites are near cereal paddocks, and it is probably not feasible to collect these data for this project.

In Vic there is some information on lerp abundance at monitoring sites, but this data is sporadic and will be of limited use in the analysis of population trends.

SUMMARY	NSW	SA	Vic	WA
15. Information on food pulses (uncorrelated with rainfall)	No	No	Some	No

Gap 15: Poor knowledge of food pulses caused by cropping and lerp outbreaks.

Remedy 15: None. It does not appear that these data can be obtained for this project in a form that is useful for analysis.

16. Environmental GIS attributes (soil, habitat, veg classes)

Although site attributes such as soil type and vegetation class do not change in time, trends in Malleefowl populations may nonetheless be associated particular attributes. These attributes are mapped in each state and available as GIS layers, but typically there is little agreement with classifications across state borders. National data set also exist and will be more appropriate for this project. These data have not yet been obtained.

SUMMARY	NSW	SA	Vic	WA

16. Environmental GIS attributes	No	No	No	No

Gap 16: No information yet collated on monitoring site soil and habitat classifications.

Remedy 16: National data at an appropriate scale will be sourced through the National Land and Water Resource Audit, AUSLIG or other national mapping resources.

Table 4. Summary table showing desirable data standards and progress within each state.

SUMMARY	NSW	SA	Vic	WA
Internal to monitoring protocols				
1. Accurate records of nests used for breeding	Yes	Yes (mostly)	Yes	Unclear*
2a. Ability to validate/vet	No	Mostly	Yes	Variable
2b. Data suitable for examining effectiveness of monitoring protocols	No	Variable	Yes	No
3. Standard areas for comparison across time	Yes	Mostly	Yes	No
4. Monitoring site locations	Yes	Yes	Yes	Mostly
5. Several years of data from each monitoring site	Yes	Mostly	Yes	Some
6. Annual monitoring	Yes	Mostly	Yes	Some
7. All nests usually checked within areas	Yes	Variable	Yes	No
8. Regular re-searching of sites	N/a	Yes	Mostly	Mostly
9. Fox and other species abundance data available	No	Mostly	Yes	No
Information External to monitoring protocols				
10. Information on fox control near monitoring grids, and over the duration of monitoring	Yes	Yes	No	Mostly
11. Information on major herbivore changes or control	No	Some	No	No
12. Information on landscape context	No	Yes	Yes	No
13. Information on climate	No	No	Yes	No
14. Information on fire history	No	No	Yes	No
15. Information on food pulses	No	No	Some	No
16. Environmental GIS attributes	No	No	No	No

Table 5. Summary of gaps identified in this report and how they will be remedied.

Gaps	Remedy
Gaps for which there is no remedy	
Gap 2a.Insufficient data to vet many records from SA and WA for trend analysis.	None
Gap 6: Not all sites have been monitored on a regular basis.	None
Gaps needing more information	
Gap 8a: Incomplete knowledge of the frequency at which grids have been re-searched in WA.	Ask for more information
Gap 10: In Vic there is little or no information on fox baiting at or near monitoring sites before 2000.	Ask for more information
Gap 11: Knowledge of major changes in herbivore numbers caused by management (ie. extensive culling, poisoning or water closures) and of control works	Ask for more information
Gap 13: Incomplete rainfall record for most sites outside Vic.	Purchase data
Gaps requiring further investigation	
Gap 1. Errors or uncertainty in activity	Further checking
Gap 3a: Lack of areal standards	Further investigation
Gap 3b: Poor understanding of how accurately measures of the proportion of nests active each year reflects the breeding population density.	Further investigation
Gap 4: Uncertain geographic location of some monitoring sites	Further investigation
Gap 8b: Incomplete understanding of the effect of not re-searching each site each year on activity estimates.	Further investigation
Gap 9b: Observers vary markedly in their ability to recognise prints and scats. It is not known how this effects relative abundance trends, but there is potential for bias.	Further investigation
Gap 12: Landscape values not yet estimated for monitoring sites in WA that will be used in the analysis.	Further investigation
Gap 14: Incomplete fire history records for sites in terms of the year sites were last burnt, the proportion burnt, and the occurrence of large fires in the vicinity.	Further investigation
Gap 16: No information yet collated on monitoring site soil and habitat classifications.	Further investigation
Gaps that will result in limiting analysis to particular data sets	
Gap 2b.Incomplete data sets for examining the effectiveness of monitoring protocols in all areas except Vic.	Limit analyses of effectiveness to Vic data
Gap 5: Not all sites have been monitored enough times to show changes in breeding numbers or nest features.	Limit trend analysis to sites with at least 3 seasons of data
Gap 7: In SA and WA, not all nests visited during monitoring and resulting uncertainty in the actual number nests used for breeding.	Limit analyses to more reliable estimates.
	Model uncertainty.
Gap 9a: Presence/absence of fox and other animal signs has not been collected at Malleefowl nests in NSW and WA.	Limit analyses
Gap 15: Poor knowledge of food pulses caused by cropping and lerp outbreaks.	Omit from analyses

Discussion and conclusion

In this report we have identified a number of gaps between what we would like to have and what we actually have in order to analyse the national Malleefowl monitoring data (Table 4). Some of these gaps relate to the monitoring information itself, and these will effect both the analysis of population trends and the review of the monitoring data. Other gaps relate to external data that would be desirable for the trend analysis so we can better understand what may be causing the trends we observe.

Gaps may be characterised in regard to their remedies (Table 5). Some gaps have no remedy because they relate to monitoring data that does not exist, but these gaps can be ignored or dealt with statistically in analyses. In other cases, gaps may be remedied by limiting analyses to particular data sets, or by leaving out some desirable environmental variable from the trend analysis. While limiting analyses is unfortunate, these problems are major issues and will in not reduce the value of this project or the importance of its outcomes.

The most important gaps identified in this report are those that we can remedy by obtaining more information or investigating the monitoring data more carefully. The project would benefit from more information on a range of subjects, and we are collating this information and in most cases expect to have what we need for the analyses. Of greater concern and importance is information on past management, especially fox control. Foxes have been implicated in the decline of Malleefowl but their effect on Malleefowl populations remains unclear and controversial. The current project provides the best chance we have to examine the benefits of fox control, and it would be a shame if this question could not be examined for lack management records.

Other information that we still require (in some locations) includes when major changes in herbivore abundance occurred. High densities of sheep and goats may severely impact on Malleefowl populations and it would be valuable to have information on changes in these species abundance over the time during which Malleefowl were monitored at sites. This information is probably best obtained from local land managers as is likely to be anecdotal. Other species that are of interest include both rabbits and kangaroos, and land managers may once again be in the best position to identify years in which these populations changed, and when important management works were undertaken. Over the next few weeks we will circulate simple questionnaires in an effort to collect this information in a systematic way.

We are also lacking information on fire history, climate, and soil and habitat classes, but in each of these cases the gaps are easily remedied and the information should be complete within a few weeks.

The final group of gaps in Table 5 includes issues where further data checking and investigation is required. Some of these issues will be dealt with as part of the next phase of this project: the review of the effectiveness of monitoring and the analysis of trends.

In general, the data needed for the analysis in the final phase of this project is taking shape and we expect to begin analyses within a month. Data that we are unable to obtain in the next four weeks will probably not be included in the analyses. While the

monitoring data is patchy in detail, overall it provides high quality data which is unique and of great value. Nationally there are about 50 sites across Australia at which Malleefowl breeding density has been monitored for at least three seasons and we expect to use most of these in the analysis of trends. The most pressing gap we have identified concerns a patchy record of past management at many monitoring sites, especially in regard to fox control in Victoria.

For the review of monitoring data we will examine the usefulness of routinely collected data. Geographic spread is not as important for this analysis and we will limit the focus to the Vic data set, which is the most complete, most consistent and largest of the state data sets comprises nearly half the total number of grids and nests monitored across Australia. Data from other states will be included where needed in examining some questions, but the focus will be on how well the original data protocols have performed, and this will provide a firm basis from which to design future Malleefowl monitoring programs.

Appendix 1: Update on monitoring data collation

NSW

Monitoring data from Mallee Cliffs (1989-2005) and Tarawi (1997-2005) have been provided and total 3,073 records. These data indicate whether or not known nests in these reserves were used for breeding, but do not include other nest data.

SA

Monitoring data from SA has been pieced together from six different sources. Combining these data has been a time consuming process due to formatting issues, sorting and filtering of duplicate data from different sources, identification of missing records, and other data integrity issues. All of these sources used original data records with the exception of the table "All_mound_history" supplied by DEH in which secondary sources, such as summaries and reports, were also used in compiling a table showing whether or not each nest was used for breeding in each season.

Table 6. Data sources for compilation of SA Malleefowl monitoring records.

Data source	Seasons	Records
Original SA database sent by Stuart Pillman	1989-1999	1728
Excel data in Cybertracker format sent by DEH (Sharon Gillam)	1992-2005	1679
Excel data in Cybertracker format sent by DEH (Jody Gates)	1996-1999	502
Data sheets entered onto Cybertracker by VMRG (Hawtin, Patford, Stokie and Wiseman)	1997-2003	881
Cybertracker files sent by CLM	2004-2005	222
"All_mound_history" (DEH summary compiled by Sharon Gillam)*	All	1159*

*This data source contains 4,551 summary records of nest activity, but shown here are the records for which no other information exists.

A number of decisions were made in compiling these records:

- All data were converted to the standard database format used in Vic. This standard is similar to that used in SA before the introduction of Cybertracker. some extra fields were added to the main data-table to indicate the source of the record, and what agency should be contacted to seek permission for its use.
- Where duplicate records were obtained for a given nest and season, priority was generally given to the earliest entry and the most detailed entry (these criteria tended to coincide).
- Where more than one entry was recorded for a nest in a given season (on different dates), the record closest to November was retained and a note was attached to this record indicating the other visits and summarising the results.
- Entries for which the nest number was not recorded were given an arbitrary negative nest number.
- Entries for which neither date nor season was recorded were given an arbitrary negative number for 'season' and marked as 'omit' for analysis.
- Missing records were identified by examining the previous seasons' nest lists for a grid and comparing these to the season in question. Nests that were identified in this way as missing within a season were added to the database and marked as

'not found'. Only nests that were identified as known nests and that were not marked for omission were added to subsequent lists.

- Comments were added to the 'general_notes' field to indicate any other changes made from the original record. These comments are prefaced with "JB2006:".

Currently, the SA monitoring data comprises 6,549 records of which 5,231 are records of nests that were found and monitored and 1,318 were nests that were not found when the grid was monitored. An additional 286 records exist on the database but are marked for omission from monitoring for a number of reasons (ie. the record was of a nest that was considered to be outside grid boundaries, not actually a nest, or without any information on season or date; these determinations were generally made in the early 1990s).

It should be noted that the number of records on the database represented only by the activity summary (All_mound_history) will decline as further data sheets come to light. Some data has been received recently (30/5/06) as original data sheets and has not yet been entered onto the database. Ideally, the contribution of "All_mound_history" would be minimal as it is a summary derived from secondary sources and records no details other than nest activity, season and nest identity.

VIC

No changes were made, except that the same routines used to identify and append missing records in the SA data were used on the Vic data.

WA

Data are still being collated from WA. The MPG have sent several hundred datasheets to us and most of these have been entered (below). Some data sheets have yet to be entered, but these are mostly from monitoring sites for which there is only one or two seasons of data – these data are unlikely to be useful in determining trends in this analysis but will valuable in subsequent analyses. There are three grids for which there is more than two seasons of data (Corackerup, Foster Rd, and Peniup).

Table 7. Data sources for compilation of MPG (WA) Malleefowl monitoring records.

Data source	Seasons	Records
Data sheets entered onto Cybertracker by MPG (Carol Nicholas)	2001-2005	233
Data sheets entered by VMRG (JB)	1993-2002	322

The NCMPG have also sent us data, although these are mostly in the form of summaries. 181 records of individual nest records have been received and entered onto the database, but otherwise the information sent to us comprises the site name, the number of nests deemed active, the total number of nests found, and the season. Not all nests were visited every season and there are uncertainties regarding these data. Although the NCMPG is involved in eight monitoring sites, most of these are recent and only two have more than two seasons of data (Nugadong and Old Well Reserve). We are currently working through the data from these two sites with the NCMPG in order to correctly interpret these results, and will then create appropriate records in the database.

Appendix 2. Summary of data by site

Table 8. Summary of monitoring data by sites. Asterisks indicate sites for which there is at least three seasons of data. 'No. seasons' shows the number of seasons in which at least some of the nests at a site were monitored. The year a site was established indicates the year in which the site was set up for monitoring and may differ from when monitoring data was first collected. In some cases in Vic, monitoring sites were established in areas where there was detailed historical data and the first year of data pre-dates the establishment of a site. In other cases, data does not appear to have been collected for several years after a site was established. Some data are still being collated and blank cells in the table indicate a lack of information or uncertainty.

State	#	Site name		No. seasons	Established	1st mon. year	Last mon. year	Avg nests	Avg mon.
New South Wales									
n	01	Mallee Cliffs	*	16	1989	1989	2005	148.00	147.90
n	02	Tarawi	*	8	1997	1997	2005	88.40	88.40
South Australia									
S	01	Cowell (1&2)	*	10	1995	1995	2005	48.5	44.6
S	03	Cooltong CP	*	13	1993	1993	2005	44.3	40.6
S	04	Calperum Oakbore		2	1996	1996	2005	14.0	8.0
S	05	Dangali 1	*	10	1993	1993	2005	14.6	11.2
S	06	Pooginook	*	15	1990	1990	2005	31.9	29.3
S	07	Bakara	*	15	1989	1989	2005	64.6	55.2
S	08	Shorts	*	14	1989	1989	2005	52.8	37.2
S	09	Chowilla	*	8	1994	1995	2005	19.9	19.0
S	10	Ferries McDonald	*	13	1990	1989	2005	60.7	40.9
S	11	Innes	*	6	1991	1992	2005	45.2	27.7
S	13	Mount Scott	*	7	1993	1992	2005	28.3	20.3
S	15	Dangali 2	*	10	1993	1993	2005	6.8	5.7
S	16	Munyaroo	*	3	1998	1998	2005	36.3	33.0
S	17	Hincks	*	4	1998	1998	2005	35.0	32.5
S	18	Pinkawillinie	*	3	1998	1998	2005	24.3	21.0
S	19	Taylorville	*	3	1999	1999	2005	37.0	24.3
S	21	Dry Frogamerry	*	3	1999	1999	2005	57.0	29.3
S	22	Overflow South		2	2004	2004	2005	5.0	5.0
S	23	Overflow North		2	2003	2004	2005	3.0	3.0
S	24	Timor West		2	2000	2004	2005	15.0	13.0
S	25	Timor Central		2	2004	2004	2005	1.0	1.0
S	27			1		2005	2005	1.0	1.0
S	29	Ral Ral		2	2003	2004	2005	14.0	14.0
S	30	Stony Pinch 1		2	1999	2004	2005	10.0	10.0

State	#	Site name		No. seasons	Established	1st mon. year	Last mon. year	Avg nests	Avg mon.
S	35	Taylorville West		2	2004	2004	2005	6.0	6.0
S	36	Taylorville East		2	2004	2004	2005	3.0	3.0
S	44	Peebinga	*	3	2001	2001	2005	61.0	52.7
S	45	Karte		2	2001	2001	2005	21.0	19.5
S	46	Billiatt		2	2001	2001	2005	13.0	11.0
S	47	Ngarkat 1		2	2001	2001	2005	9.0	8.5
S	48	Ngarkat 2		2	2001	2001	2005	7.5	4.5
S	49	Ngarkat 3		2	2001	2001	2005	18.0	12.5
S	52	Gluepot 3		2	2000	2004	2005	27.0	18.0
S	54	Gluepot 5		2	2000	2004	2005	16.0	15.5
S	56	Gluepot 7		2	2000	2004	2005	14.0	13.5
S	57	Gluepot 8		2	2000	2004	2005	10.0	9.5
S	59	Gluepot 11		2	2000	2004	2005	12.0	12.0
S	60	Gluepot 12		2	2000	2004	2005	16.0	15.0
S	63	Gluepot 15		2	2000	2004	2005	13.0	13.0
S	64	Lock	*	3	2003	2003	2005	49.3	48.0
S	65	Coorong	*	9	1996	1996	2005	25.6	12.3
Victoria									
V	01	Dattuck	*	12	1994	1994	2005	73.8	71.3
V	02	Torpey's	*	21	1986	1962	2005	44.8	42.8
V	03	Wathe SW	*	18	1986	1986	2005	74.8	70.9
V	04	Bronzewing	*	17	1986	1986	2005	81.0	79.4
V	05	Colignan	*	9	1996	1996	2005	13.7	13.7
V	07	Annuello	*	17	1986	1986	2005	30.1	26.6
V	08	Powerline	*	10	1996	1996	2005	15.1	15.1
V	09	Mt Hattah	*	10	1996	1996	2005	10.7	10.7
V	10	1 Tree BNT	*	5	1996	1996	2005	3.0	3.0
V	11	Mopoke	*	10	1996	1996	2005	10.5	10.5
V	12	Pheeneys	*	13	1991	1991	2005	19.8	19.6
V	13	Bambill	*	12	1994	1994	2005	32.3	32.3
V	14	Menzies	*	13	1991	1991	2005	24.8	24.4
V	15	Wandown	*	18	1989	1969	2005	64.2	60.1
V	16	South Bore	*	12	1994	1994	2005	38.9	36.4
V	17	One Tree Plain	*	10	1993	1993	2005	32.7	31.7
V	18	Washing Machine	*	13	1993	1993	2005	23.7	23.4
V	19	Cowangie	*	13	1993	1993	2005	19.2	17.5
V	20	Lowan	*	15	1989	1989	2005	42.5	41.6
V	21	Dumosa	*	14	1992	1992	2005	30.6	30.1

State	#	Site name		No. seasons	Established	1st mon. year	Last mon. year	Avg nests	Avg mon.
V	22	Denning	*	12	1992	1992	2005	17.3	15.8
V	23	Moonah	*	13	1994	1984	2005	58.3	58.0
V	24	Kiata	*	5	1999	1999	2005	19.4	19.2
V	26	Hattah Tracks	*	4	2004	1991	2005	20.3	19.3
V	27	O'Brees	*	4	2002	2002	2005	20.0	20.0
V	28	Nurcoung		2	2004	2004	2005	12.0	12.0
V	29	Wedderburn		2	2004	2004	2005	9.0	9.0
V	30	Hattah South		2	2004	2004	2005	11.0	11.0
V	31	Skinners Flat		1	2005	2005	2005		
V	32	Wychitella		1	2005	2005	2005		
V	33	Korong Vale		1	2005	2005	2005		
Western Australia									
W	01	Nugadong	*	6	1996	1996	2004		
W	02	Old Well Maya			1998	1998	2005		
W	?	Maya		1	1998	1998	1998	4.0	
W	?	Eatons (?07)		1	2004	2005	2005	10.0	
W	?	Carters		1	2004	2004	2005	32.0	
W	?	Reudaveys		1	2005	2005	2005	34.0	
W	?	Mt Gibson			2005	2005	2005		
W	?	White Wlls			2005	2005	2005	21.0	
W	11	Corackerup	*	8	1993	1993	2004	37.6	24.1
W	12	Foster Rd	*	7	1998	1998	2004	24.6	16.0
W	13	Peniup	*	8	1998	1998	2005	17.5	13.5
W	14	Hills		3	1999	1999	2002	16.0	9.0
W	15	Tieline Rd		2	1998	1998	2001	15.5	
W	16	Yeleerie		2	2000	2000	2004		
W	17	Mt Jackson							
W	18	Eyre		1	2005	2005	2005	48	
W	19	Hidden Valley (Mullewa)			2001			14	
W	20	Kalgoorlie							
W	21	Merredin							
W	?	Windarling		1					