12. Reproductive outputs of two comparable regions of the South Australian Murray–Darling Basin – Results and learnings for recovery

Chris Hedger, Department of Environment, Water and Natural Resources South Australia; Member National Malleefowl Recovery Team

Abstract

What started as a project to determine if plague locust spays had any obvious effects on Malleefowl reproductive output (no detectable impacts), soon developed into a much more versatile project. Regular nest excavations were utilised to monitor the reproductive output across the breeding season at a number of nest sites south of the River Murray in the 2010-2011 breeding season. Subsequent surveys the following year were carried out across a similar number of sites north of the river where grid monitoring indicated greatest regional concern. The results from both these surveys will be explored and results will be stacked up against one another. Comparisons will also be made between historic and national results elsewhere to provide perspective. Further discussion will then demonstrate how these results have improved regional understanding of Malleefowl productivity and helped to refine regional recovery prioritisation foci.

Background

The Malleefowl is a prominent threatened species within the mallee landscapes of the South Australian Murray-Darling Basin Natural Resources Management Region. Its size and widespread conspicuous use of dirt mounds as a breeding tool has cemented its place as a flagship species for the wider community of threatened mallee birds within this region. This degree of general community fascination has led to the successful rollout of annual mound monitoring across 20 grids within the region over the last 15 years. Direct comparisons of these surveys results highlight a distinct difference between populations north and south of the River Murray (see Figure 1) (Packer *et al.*. 2014). The northern landscape (hereafter Bookmark), has consistently registered lower active mound densities than the southern (hereafter Murray) landscape, indicating Bookmark is traditionally less productive than the Murray landscape.

Trajectories of the two landscapes have largely followed similar trends, with peaks and troughs of both landscapes replicated similarly across the timeline. However since the end of the millennium drought in the late 2000's and the onset of the significant La Nina event in 2010-2011 the two landscapes have demonstrated greater disparity in response indicating that the Bookmark landscape is less capable of responding to highly productive periods.

During this La Nina event in 2011, widespread locust plagues across the region resulted in an extensive spraying program by Primary Industries and Resources South Australia (PIRSA). As an attempt to assess potential impacts on native fauna, PIRSA approached regional staff from the Department of Environment, Water and Natural Resources (herein DEWNR) to assess for pesticide uptakes and potential impact on nesting success at numerous sites across the Murray Mallee. Whilst the results of this study revealed no observable impacts (Ryan-Colton *et al.*. 2011), the data collected proved useful in highlighting reproductive outputs of Malleefowl across this landscape during periods of high resource availability and rainfall. In light observed differences between these two landscapes at the grid level it was decided that a similar study the year after (still pulsing from La Nina event) in the Bookmark landscape might help to draw out rationales behind landscape differences.

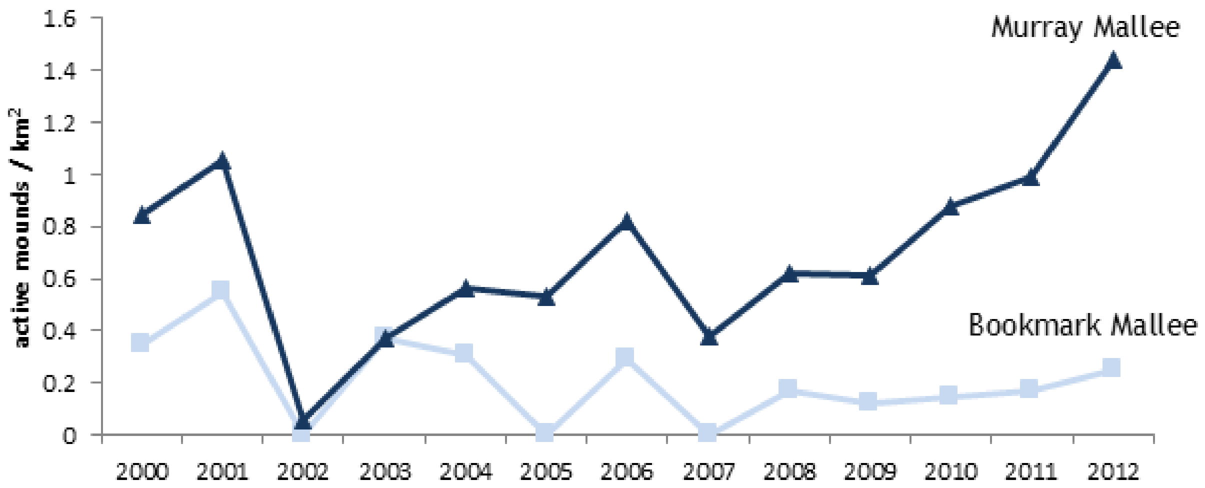

Figure 1. Comparison of active nest densities within Bookmark (northern) and Murray (southern) mallee landscapes between 2000 and 2012 (National Malleefowl Recovery Team 2015, Packer *et al.*. 2014).

Methodology

Study site

Within each landscape, a spread of grids were selected to attempt to capture variation and reduce bias. Within these individual nests were chosen based on availability of active nests at the time, these locations can be seen in Figure 2. Despite considerable effort to attain more sample sites, the existing nest density variation between the two landscapes meant that an unequal number of mounds was surveyed in each; Bookmark (8 mounds), Murray (17 mounds).

Sampling and data collection

The methodology utilised was adopted from extensive mound excavation surveys conducted by Joe Benshemesh and Jessica van der Waag (unpublished). To minimise risk to the Malleefowl initial surveys were supervised by Joe, to ensure appropriate and least risk methodologies were adhered to.

Surveys began in early spring with the first mound opening and continued every three weeks to monitor egg progression and fate. The surveys were only terminated at a site when it was clear that the mound had been abandoned and that all remaining egg fates were accounted for. During each survey session, each mound was carefully opened to the egg chamber and eggs were counted, weighed and measured, before being returned to the nest with a unique identifying number pencilled lightly onto to the egg. Each numbered egg returned to the mound was mapped in the chamber respective to north. On subsequent trips any hatched eggs could be identified based on the presence of remaining shell and membranes, observation of identifying number or relevant location based on previous mapping. Additional to this, any new eggs were completely sampled, but old eggs were only reweighed to determine egg development. Standardly eggs in normal development should gradually lose weight as they grow through chorionic respiration processes (Benshemesh 1992, Vleck *et al.*. 1984), therefore any eggs that failed to lose small amounts of weight over two consecutive visits, were deemed suspect and candled for signs of development equivalent to known age). Nests were not revisited when the mound ceased to be maintained by Malleefowl and all remaining eggs were clearly unviable.

Analysis of egg volume was converted from measurements taken using a conversion formula widely used by previous survey methodologies (Benshemesh 1992, Brickhill 1987, Priddel and Wheeler 2005).

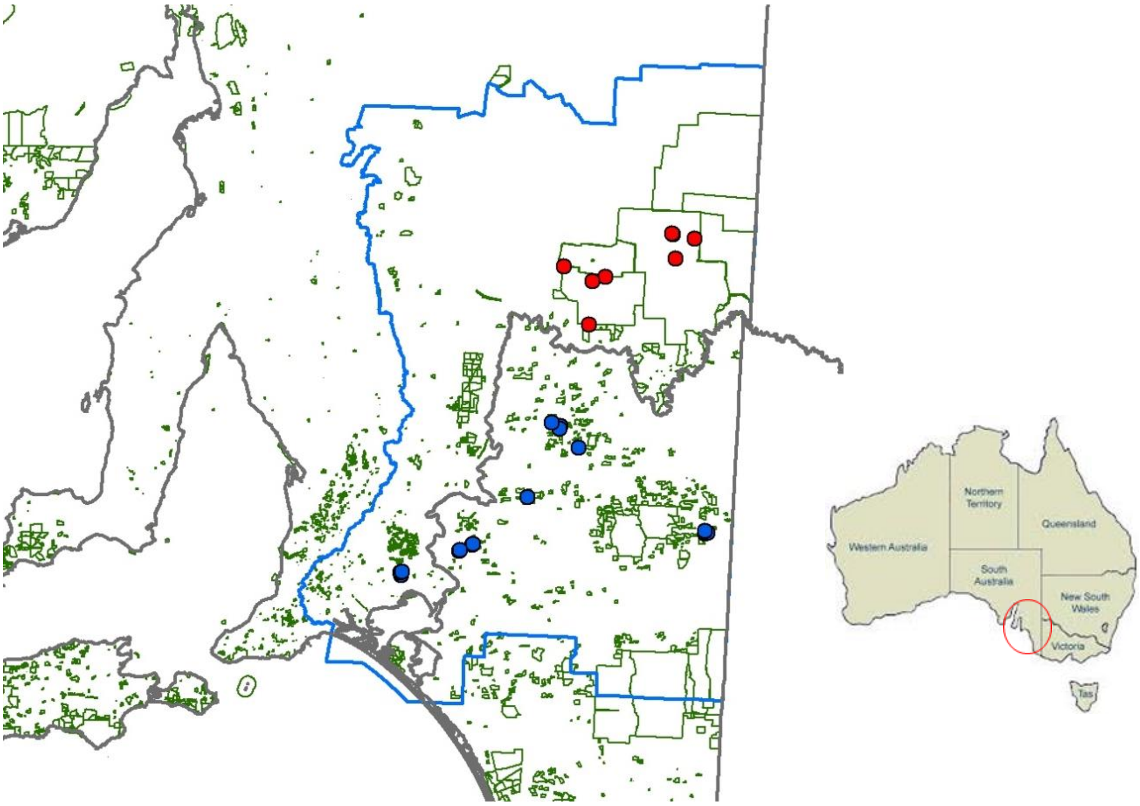

Figure 2. Nest sites sampled during combined surveys 2012-13. Blue dots indicate nest sites in Murray, whilst red dots indicate nest sites in Bookmark. Solid blue line indicates SAMDB regional boundary.

Results

Clutch size

In the Murray landscape a total of 463 eggs were laid across the 17 sites, giving an average of 27.2 eggs per mound. A number of mounds exceeded 40 eggs, whilst only a few were less than ten. The highest number of eggs laid for one mound was 47, with the lowest being four. Figure 3 highlights the spread of results across the mounds.

In contrast the Bookmark landscape demonstrated lower figures, with 160 eggs laid across the eight mounds surveyed. The average mound yield was 20, with five of the eight mounds exceeding this average. The highest number of eggs laid in one mound was 26, with the lowest being ten. Figure 4 highlights the results from across the surveyed mounds.

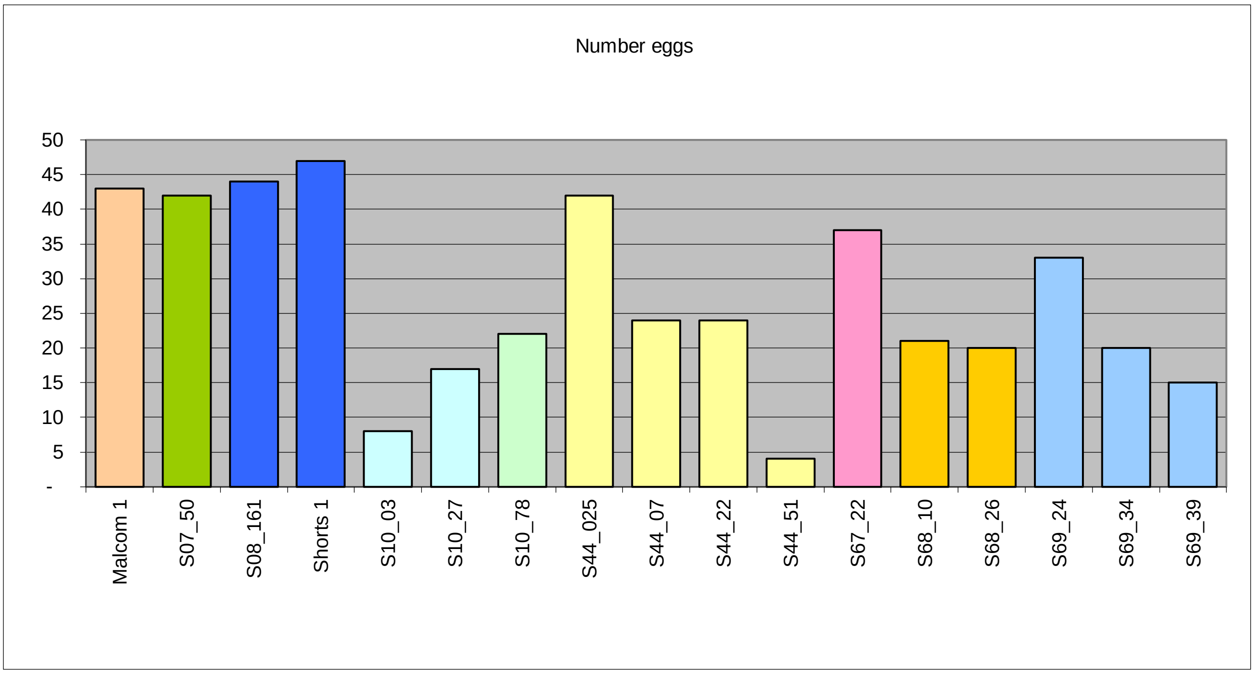

Figure 3. Murray landscape clutch size results per mound, colours indicate mounds in the same grid.

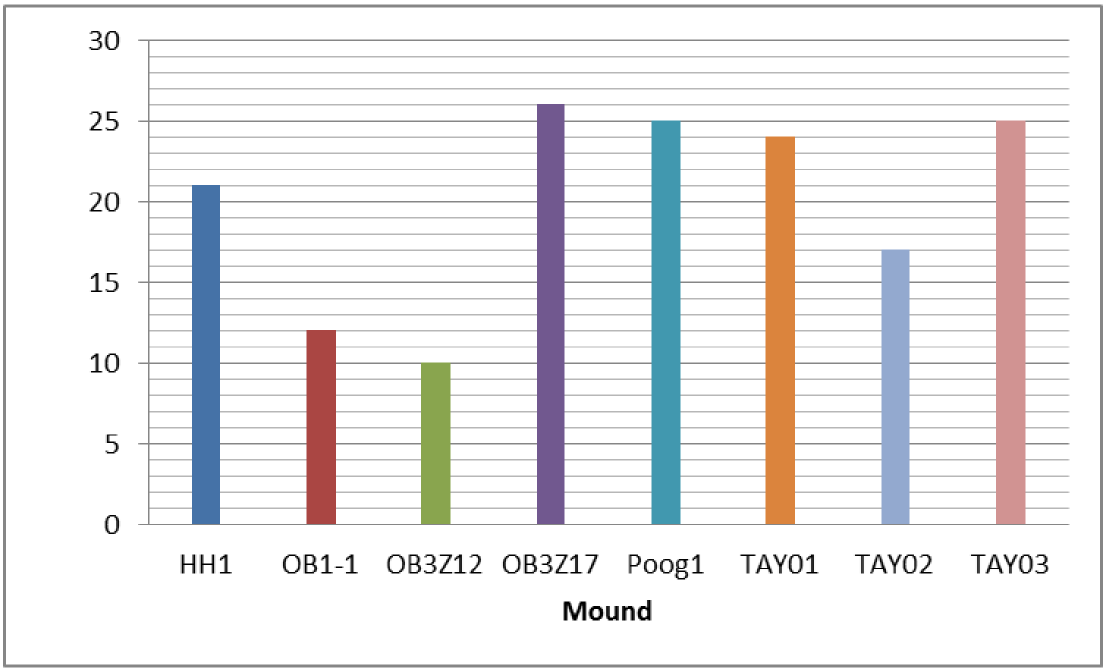

Figure 4. Bookmark landscape clutch size results per mound.

Hatching Success

In the Murray Mallee landscape a variety of hatching success ratios were noted throughout the mounds surveyed. The majority of mounds demonstrated hatching success ratios between 50% and 90% (as seen in Figure 5), with an average of 58% across all sites. Figure 6 shows the fates of eggs for the mounds in the Murray Mallee. Predation inside the mound accounted for very little of the fate, with only one mound having eggs raided by a fox during visits. Predation outside the mound was difficult to survey but was noted as being lightly scatted across the sites.

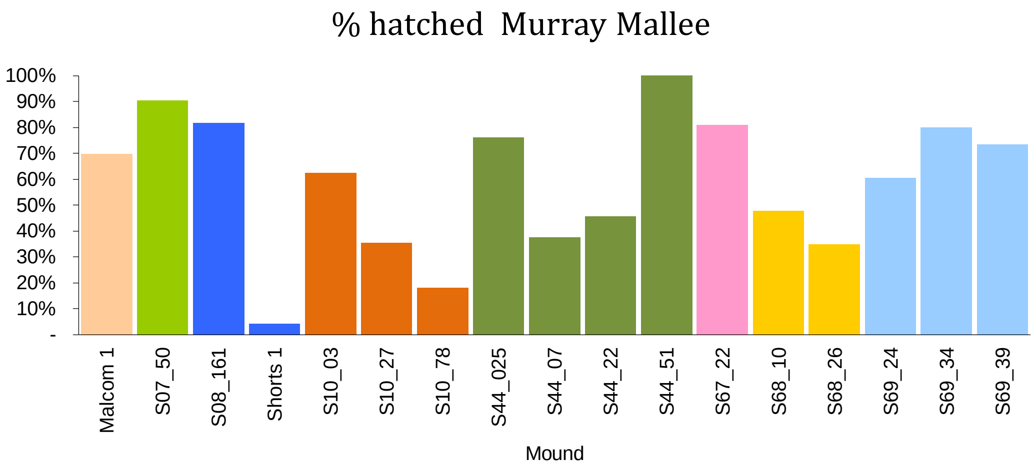

Figure 5. Spread of hatching success at all mound sites in Murray Mallee landscape, colours indicate mounds in the same grid.

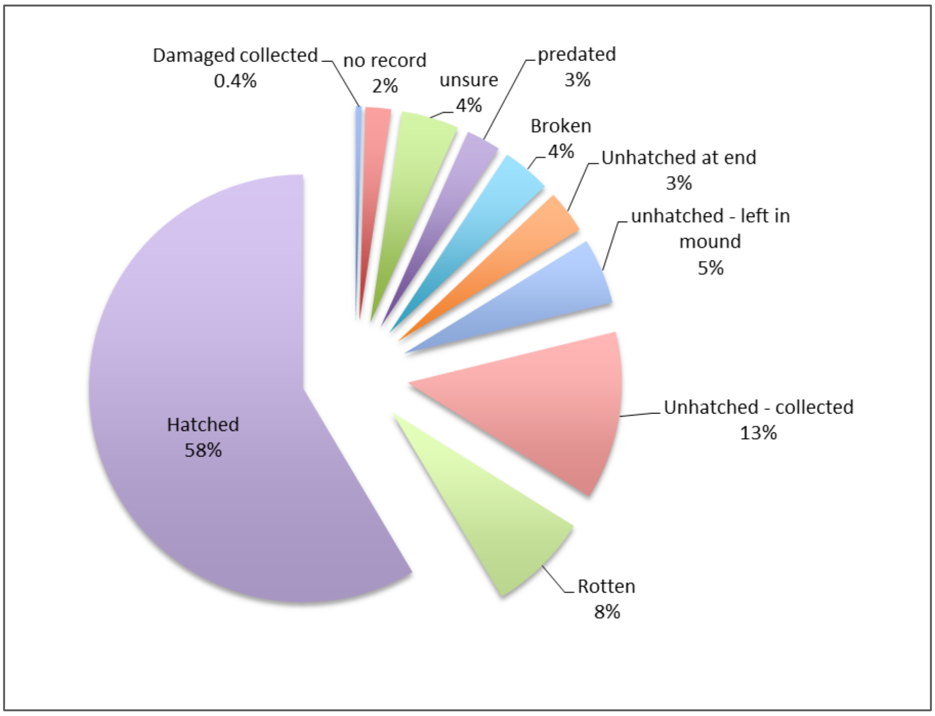

Figure 6. Fate percentages for the collective Murray Mallee mounds.

In the Bookmark landscape hatching percentages were fairly uniform across all the sites, ranging between 60% and 100% (as seen in Figure 7). Only one site (OB3Z17) demonstrated poor hatching success ratios, with less than 20% of eggs successfully hatching. The average successful hatching percentage across the sites was 68%, ten percent higher than the Murray Mallee landscape. Nineteen percent of eggs were unaccounted for in these surveys, due largely to sudden emptying of the nest by adults between visits. This final clearing of the nest at the end of the season, was not noted in the Murray Mallee landscape, however it is likely that the majority of these unaccounted eggs failed to hatch due to cooling chambers or premature ejection. No predation within the mound was noted, although several attempts were noted on large mounds during surveys. It was noted that at OB3Z12 (where hatching success was very low), nest abandonment coincided with evidence of adult bird attack (extensive gatherings of adult feathers around the mound). Although not quantified, predation outside the immediate nesting area, appeared to be significantly more regular across this landscape, compared to the Murray Mallee.

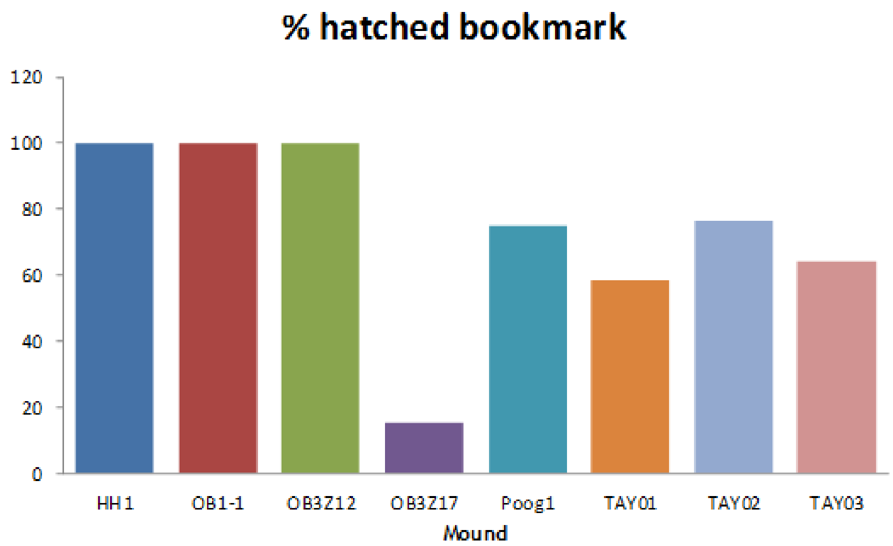

Figure 7. Spread of hatching success across all sites in the Bookmark mallee.

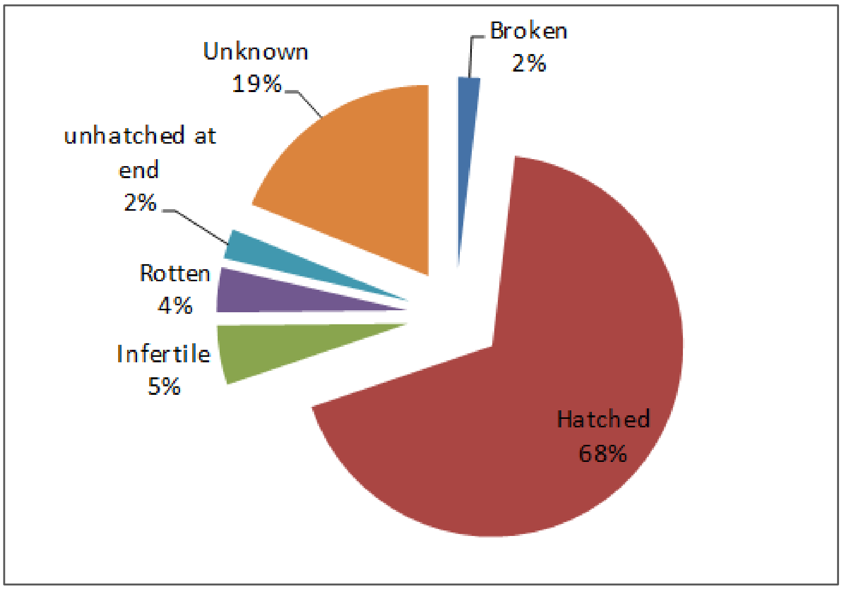

Figure 8: Fate percentages for the collective Bookmark landscape.

Egg size and Volume

Egg volume in the Murray Mallee landscape was uniformly variable across the board (see Figure 9). The average egg volume across the landscape was 168ml. The largest average egg volume per mound was 183ml at Murray Bridge army range, with the lowest being 155ml at Peebinga. The only specific trend at sites with more than one nest sampled was seen at Murray Bridge army range, where volumes were consistently amongst the highest.

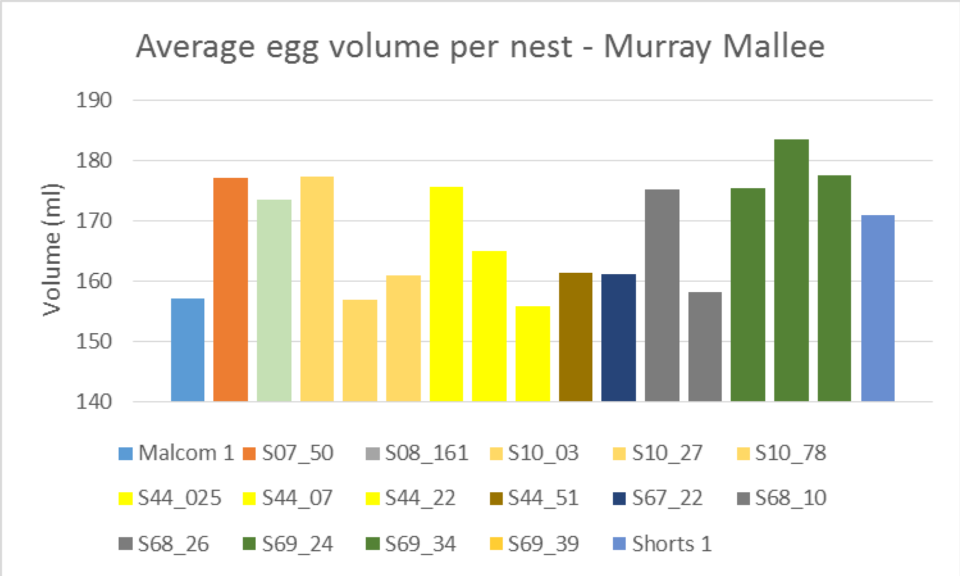

Figure 9. Average egg volumes per nest across the Murray Mallee landscape.

Egg volume in the Bookmark mallee landscape was highly variable (see Figure 10). The average egg volume across the landscape was 160ml. The largest average egg volume per mound was 182ml, with the lowest being 134ml. As sites were spread across the landscape with little foci areas, no general trends across specific areas can be determined.

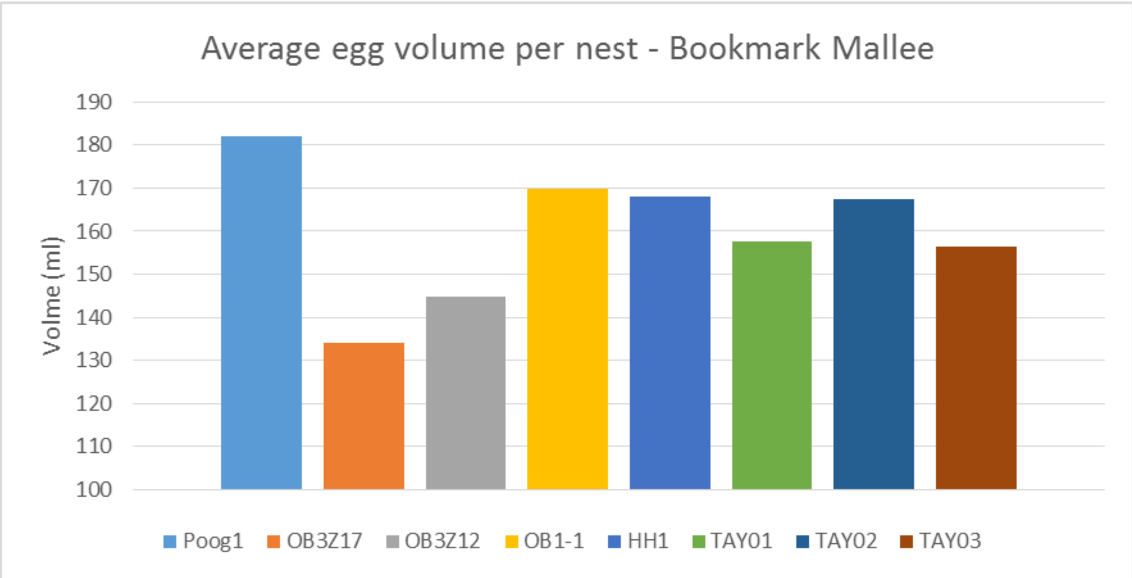

Figure 10. Average egg volumes per nest in the Bookmark mallee landscape.

Overall productivity

Overall productivity represents the total number of chicks hatched from each mound, and is a direct culmination of both clutch size and hatching success. The number of chicks varied considerably across the Murray Mallee, with an average of 15.3 chicks per mound successfully hatched. The highest number of chicks successfully hatched was 37, with the lowest being two. Looking into specific sites, Ferries Macdonald sites (highlighted below in light blue – s10) demonstrate a consistently low output, with six or fewer eggs hatched per mound.

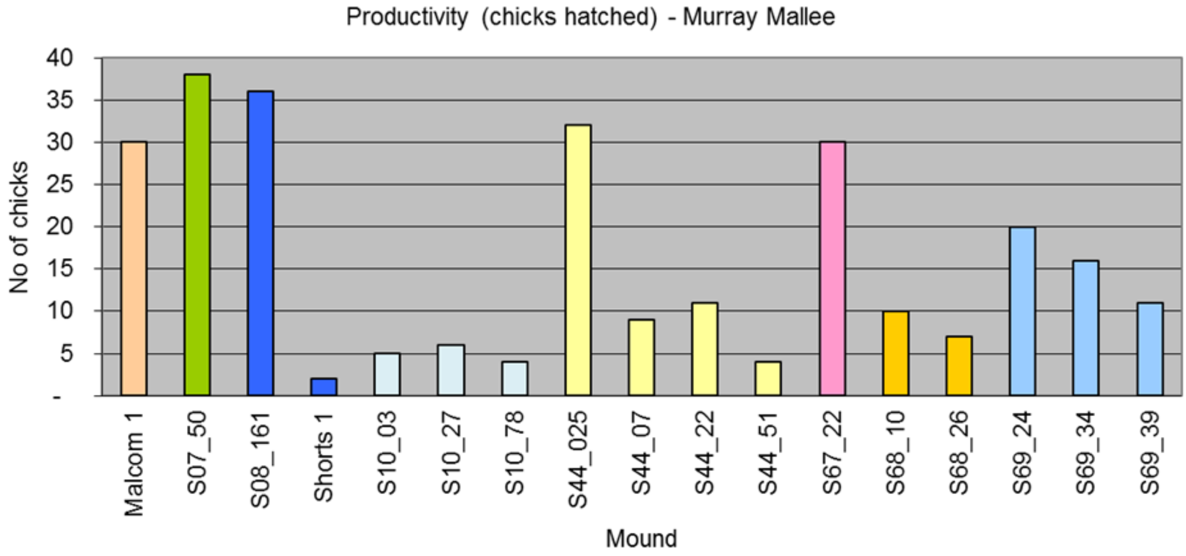

Figure 11. Productivity in Murray Mallee, colours indicate mounds in the same grid.

Productivity numbers across the Bookmark mallee were considerably less variable, with average outputs per mound between 10 and 20 chicks. The average was number was 13, with OB3Z17 having the lowest output at three chicks, and HH1 having the highest at 21.

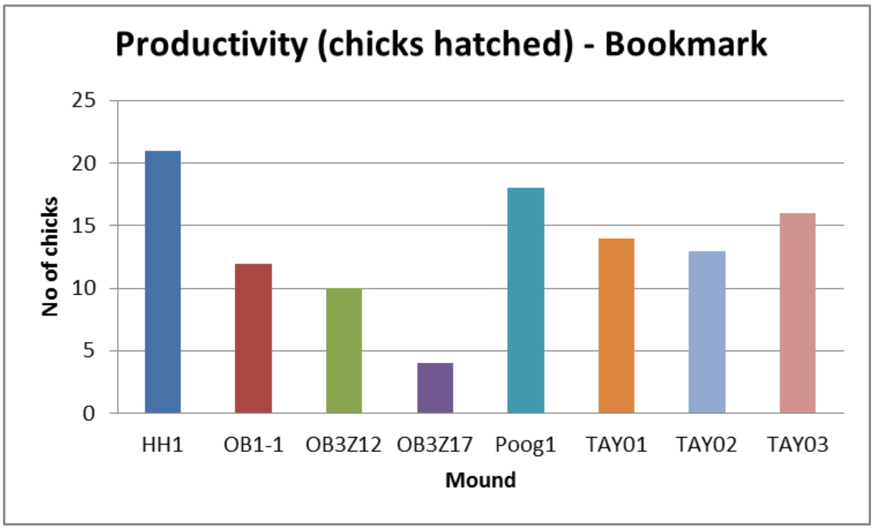

Figure 12. Productivity in the Bookmark mallee.

Comparisons between historic national data

Comparisons of historic productivity surveys both at a landscape (where available) and a national level reveal some interesting findings. Table 1 below highlights the basic figures for all of these.

Table 1. Average survey statistics for project surveys results compared to historic survey effort. Brackets in fields indicate number of separate studies sourced (Priddel *et al.*. 2007, Booth 1987, Burton 2000, Frith 1959, Brickhill 1987, Gillam 2008, Benshemesh 1992, Benshemesh *et al.*. 1997).

Average variables	Murray Mallee 2010-11	Bookmark 2012-13	Murray Mallee historic (0)	Bookmark historic (2)	National (7)
Clutch size (n)	27.2 (4-47)	20 (10-26)	-	9(2-15) & 14(2-34)	14-19.8 (1-34)
Hatching success	58%	68%	-	56% & 79%	50-85%
Egg volume (mean)	170.8ml	162ml	-	-	160-168ml

Murray Mallee landscape figures have no prior reference surveys to compare against, but when compared to the averages highlighted at the national level, it demonstrates a significant positive deviation from the norm. This is especially true for maximum clutch size in any one nest (47 versus 34) and average clutch sizes across all mounds (27 vs max 19.8). Mean egg volumes were also up against previous landscape averages (170.8ml vs max 168ml).

Figures from the Bookmark landscape fit within national averages more generally, but when compared against historical surveys within this landscape, it shows mixed results. Paul Burton recorded much lower averages in clutch size and hatching success in 2000 (Burton 2000), however David Booth recorded higher average clutch sizes and greater hatching success in the early 80's (Booth 1987).

Conclusion and discussion

The period during which the surveys were conducted was within or immediately after a significant La Nina period for most of the country. No previous historic survey effort used as reference for national standards refers to specifically to such events such as these, and thus likely explains the significant differences between both landscape and national comparisons. Results from these surveys strongly suggest that Malleefowl in general are capable of increasing productivity outputs in response to increases in resource availability. Historic survey efforts elsewhere confirm the impact of significant rainfall events as key to increases in laying season and interval period (Priddel and Wheeler 2005, Benshemesh 1992). This response is likely to play an important role in all Malleefowl populations, especially in more arid parts of their range where standard climatic conditions are likely to produce poor productivity outputs. Chick survivorship is largely contributed to availability of food and water, along with levels of predation (Priddel and Wheeler 1990, Priddel and Wheeler 1994, Priddel and Wheeler 1997). In a moisture and resource rich environment such as those seen during the period of these surveys, these pressures are likely significantly relieved, and an increase in potential fledging recruitment rates into the wider functional population are speculated to occur (Priddel and Wheeler 1990, Priddel and Wheeler 1994, Priddel and Wheeler 1997, Benshemesh *et al.*. 1997). As aridity levels increase across the species range, responses to such events at the mound level are likely to be even more critical to replacement and long term persistence of the species within a given area.

The differences between the two landscapes studied in the project, begin to shed some light into reasons why national grid data also shows a clear distinction between these two landscapes (Figure 1). When compared to the Murray Mallee the Bookmark mallee landscape demonstrated lower average clutch sizes, lower egg volumes and decreased productivity outputs. The differences between these landscapes are largely unsurprising. It is plausible this is primarily caused by climatic differences between the two landscapes, and its flow on effect on palatable resource availability or resource response rates. Mean rainfall differences between these two landscapes can be up to 120mm in places. Studies as early and Henry Frith's in the 1950's confirm these correlations between local climate and productivity (Frith 1959). However, the disparity between this study and the one of Brickhill in the 1980's (Brickhill 1987), even given the boom in resources, suggests that some of the results seen in the Bookmark may not be purely geographic variation in climate, but rather that this landscape may have at least temporarily lost some of its capacity for this species. Climate change is the most obvious potential contributor to this and widespread reductions in winter and annual rainfall across this landscape (Setchell 2011) go some way to confirming this.

Several historic examples across the country highlight the positive correlation between initial egg volume scores and chick survivorship, indicating that the greater the egg volume the stronger and more resilient a successfully hatch chick will be (Benshemesh 1992, Priddel and Wheeler 1994). In the case of the Bookmark mallee, where a reduced rainfall more generally increases the odds of predation or starvation related deaths, improvements in early stage fitness are likely critical. In this particular season the low volume scores in eggs noted in this study may be offset by increased food availability and a reduction in predation pressures.

Although poorly documented in this study, the observed increase in predation around the mound in the Bookmark mallee despite likely increases in alternate prey sources, suggests that predators may inherently sustain learned hunting behaviours more readily within this landscape. The presence of apparent adult attack, also heavily noted in Brickhill's study is rare amongst other study results and supports increases in learned behaviours across this landscape (Brickhill 1987). Benshemesh and Sandell, noted sustained increases in mound predation following a dramatic reduction in alternate prey sources, and postulate that desperation invokes prey switching to more difficult food sources may initially drive increases in learned hunting behaviours, which are then sustained until population turnover (Benshemesh *et al.*. 1997). If true, this could potentially explain the increases in predation at multiple life stages across the Bookmark, as the increased aridity of this landscape likely influences increases in prey switching.

Throwing all of this together, one can begin to understand the long term differences in grid survey results between these two landscapes and furthermore the apparent lack of response to La Nina events. All suggestions point towards a loss of resilience in Malleefowl across the Bookmark mallee. Something perhaps masked by augmented food sources in more fragmented southern systems. The key for managers looking to protect this species, is to determine how best to react to this information. Are limited resources best focused on creating more resilience in this incredibly large and relatively intact landscape, or are they best focused on those populations currently most resilient and adaptable. Fox baiting for example is rolled out across both landscapes, principally for the benefit of Malleefowl, however recent publications hint that perhaps the scale and intensity is not appropriate for reducing risk to this species (Priddel and Wheeler 1997, Thomson *et al.*. 2000, Walsh *et al.*. 2012). Perhaps in this case these resources are better pooled to more effectively target foxes in the most deserving landscape? Based on previously discussed logic around increases in aridity and added predation pressures through loss of alternate prey, one could fundamentally argue its added benefit compared to more mesic systems.

The results from this project however should not be treated as the gospel and the justification for all future management considerations. It should be treated as additional data to guide and inform, or more simply a discussion to illicit more conversation or research around what we do for this species. It is critical that moving forward any attempts to address key recovery outcomes are done so in an adaptive fashion using smart, evidence based recovery tools to test and revise all actions. Often this is difficult under current funding arrangements, so extensive community engagement throughout these processes will be critical. These two landscapes and Malleefowl more generally are well placed to become pioneers in adoption of such processes as they already engage heavily with community through annual grid surveys.

Acknowledgements

These surveys would not have been possible without the help of the following key people; Joe Benshemesh, Ellen Ryan-Colton, Luke Ireland, Dave Setchell, Matt Humphrey, David Wells, Ryan Hamood, Zac Moore and Taneal Cope.

Further acknowledgement to several other key volunteers that helped throughout the surveys includes: Kevin Smith, Graham Frahn, Benita Dillon, Glenn Drogemuller, Graeme Tonkin, Malcolm Johns, Henry Short and numerous other staff and community members.

References

Benshemesh J. (1992) The conservation ecology of the Malleefowl, with particular regard to fire. Ph.D. thesis, Monash University.

Benshemesh J., Sandell P. & Burton P. (1997) Fox Predation on Malleefowl Mounds after the Spread of RHD in North West Victoria. Parks Victoria and Department of Natural Resources and Environment, Mildura.

Booth D.T. (1987) Home Range and Hatching Success of Malleefowl, *Leipoa ocellata* Gould (Megapodiidae), in Murray Mallee Near Renmark, SA. *Wildlife Research* **14,** 95-104.

Brickhill J. (1987) Breeding Success of Malleefowl *Leipoa ocellata* in Central New South Wales. *Emu* **87,** 42-45.

Burton P. (2000) Fox Predation and Breeding success of Malleefowl (*Leipoa ocellata*) near Renmark in South Australia.

Frith H.J. (1959) Breeding of the Mallee-fowl, *Leipoa ocellata* Gould (Megapodiidae). *CSIRO Wildlife Research* **4,** 31-60.

Gillam S.D. (2008) Malleefowl *Leipoa occellata* mound productivity in three regions of South Australia following a low rainfall year. *South Australian Ornithologist* **35,** 110-122.

National Malleefowl Recovery Team (2015) National Malleefowl Monitoring Database. National Malleefowl Recovery Team.

Packer J., Hedger C. & Stubbs W. (2014) Predator removal for ground-dwelling bird recruitment in the SA Murray–Darling Basin: A review of current evidence and best practice options.

Priddel D. & Wheeler R. (1990) Survival of Malleefowl *Leipoa ocellata* Chicks in the Absence of Ground-Dwelling Predators. *Emu* **90,** 81-87.

Priddel D. & Wheeler R. (1994) Mortality of captive-raised Malleefowl, *Leipoa ocellata*, released into a mallee remnant within the wheat-belt of New South Wales. *Wildlife Research* **21,** 543-551.

Priddel D. & Wheeler R. (1997) Efficacy of Fox Control in Reducing the Mortality of Released Captive-reared Malleefowl, *Leipoa ocellata*. *Wildlife Research* **24,** 469-482.

Priddel D. & Wheeler R. (2005) Fecundity, egg size and the influence of rainfall in an isolated population of Malleefowl (*Leipoa ocellata*). *Wildlife Research* **32,** 639-648.

Priddel D., Wheeler R. & Copley P. (2007) Does the integrity or structure of mallee habitat influence the degree of Fox predation on Malleefowl (*Leipoa ocellata*)? *Emu* **107,** 100-107.

Ryan-Colton E., Hedger C., Setchell D. & Benshemesh J. (2011) Effects of locust control activities on Malleefowl nesting success. In 'Proceedings of the 4th National Malleefowl Forum 2011.' pp. 118-125.

Setchell D. (2011) Malleefowl Monitoring Program: South Australian Murray Darling Basin 2010/2011 final report.

Thomson P.C., Marlow N.J., Rose K. & Kok N.E. (2000) The effectiveness of a large-scale baiting campaign and an evaluation of a buffer zone strategy for fox control. *Wildlife Research* **27,** 465-472.

Vleck D., Vleck C.M. & Seymour R.S. (1984) Energetics of Embryonic Development in the Megapode Birds, Mallee Fowl *Leipoa Ocellata* and Brush Turkey *Alectura lathami*. *Physiological Zoology* **57,** 444-456.

Walsh J.C., Wilson K.A., Benshemesh J. & Possingham H.P. (2012) Unexpected outcomes of invasive predator control: the importance of evaluating conservation management actions. *Animal Conservation* **15,** 319-328.