



SUPPLEMENTARY PEST CONTROL TRIAL FINAL EVALUATION

FEBRUARY 2017



Enquiries

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List of acronyms

IA CRC – Invasive Animals Cooperative Research Centre

LLS – Local Land Services

NPWS – National Parks and Wildlife Service

NSW – New South Wales

OEH – Office of Environment and Heritage

SPC – Supplementary Pest Control

SSAA NSW – Sporting Shooters Association of Australia NSW Branch

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Attachments

Attachment 1: Terms of Reference

Attachment 2: Evaluation framework and logic

Attachment 3: A systematic review of ground-based shooting for pest animal control, Invasive Animals Cooperative Research Centre.

Attachment 4: Strategic Alignment Report – First Person Consulting

Attachment 5: Survey questionnaire – reserve neighbours

Attachment 6: NPWS SPC Ecological and Operational Monitoring

1 Executive Summary

This report is the final in a series of three reports by the Natural Resources Commission (the Commission). The series evaluates the NSW Government-led supplementary pest control trial (SPC trial).

The long-term aim of the SPC trial is to contribute to reducing the impact of targeted pest animal species on priority threatened native species and ecological communities in national parks and other conservation reserves in NSW.

Since February 2014, the National Parks and Wildlife Service (NPWS) has managed the SPC trial in 12 parks and reserves (6 reserve complexes) across the state. This trial involves using voluntary ground shooters to assist in controlling pest animals in national parks and other reserves, as a supplementary technique to complement other NPWS pest control programs. It is scheduled and managed by the NPWS.

The Commission has been tasked with evaluating the effectiveness, efficiency and social impacts of the SPC trial, to assist the NSW Government in deciding whether, and how, to proceed with the SPC program beyond the trial period, which ends in June 2017.

Figure 1 provides an overview of the trial locations, key threatened assets, primary pests removed and volunteer days for each site.

The SPC trial has shown that using appropriately trained and capable volunteer ground shooters can deliver positive pest management outcomes and social benefits, such as improved relationships and communication between NPWS and their neighbours. The trial has also demonstrated that volunteer ground shooting can be done safely and humanely when sufficient risk management, supervision and planning are undertaken. The Commission has concluded that volunteer ground shooting has the potential to be an effective supplementary pest control technique in the state's national parks and other reserves, if used as part of an integrated pest management program under controlled conditions.

This review demonstrates that the SPC trial has resulted in an improvement in integrated pest management at participating sites, and removal of 5,655 pest animals. The Commission cannot draw firm conclusions on the conservation benefits for threatened species and ecological communities, due to the limited scale of the trial and limitations of the ecological monitoring. However, the Commission considers that were it to continue, improvements in integrated pest management arising from the SPC program are likely to further support NPWS's protection of threatened species and ecological communities.

The total cost of the SPC trial was \$5.9 million with almost 20 percent, or \$1.1 million, associated with start-up costs such as equipment, program design and establishment. Costs per planned operation have declined by around 89 percent since trial commencement and 59 percent since July 2014.

NPWS has capably and professionally managed the SPC trial with the support of the Sporting Shooters Association of Australia NSW (SSAA NSW). Both organisations have demonstrated a genuine collaborative approach, excellent team work and a willingness to share knowledge and experience. Further, the trial period has allowed NPWS to work out how centralised SPC staff can best coordinate with regional NPWS staff. Significant time and effort has gone into building these relationships and adapting the trial to date. This effort can be leveraged going forward.

The Commission recommends that the SPC program continue and be expanded beyond the trial phase provided that:

- the current safety and animal welfare standards are maintained
- drawing on the lessons from this trial, it is strategically applied where it can provide most benefit as part of an integrated pest management program
- additional funding is allocated separate from NPWS core pest management budget.

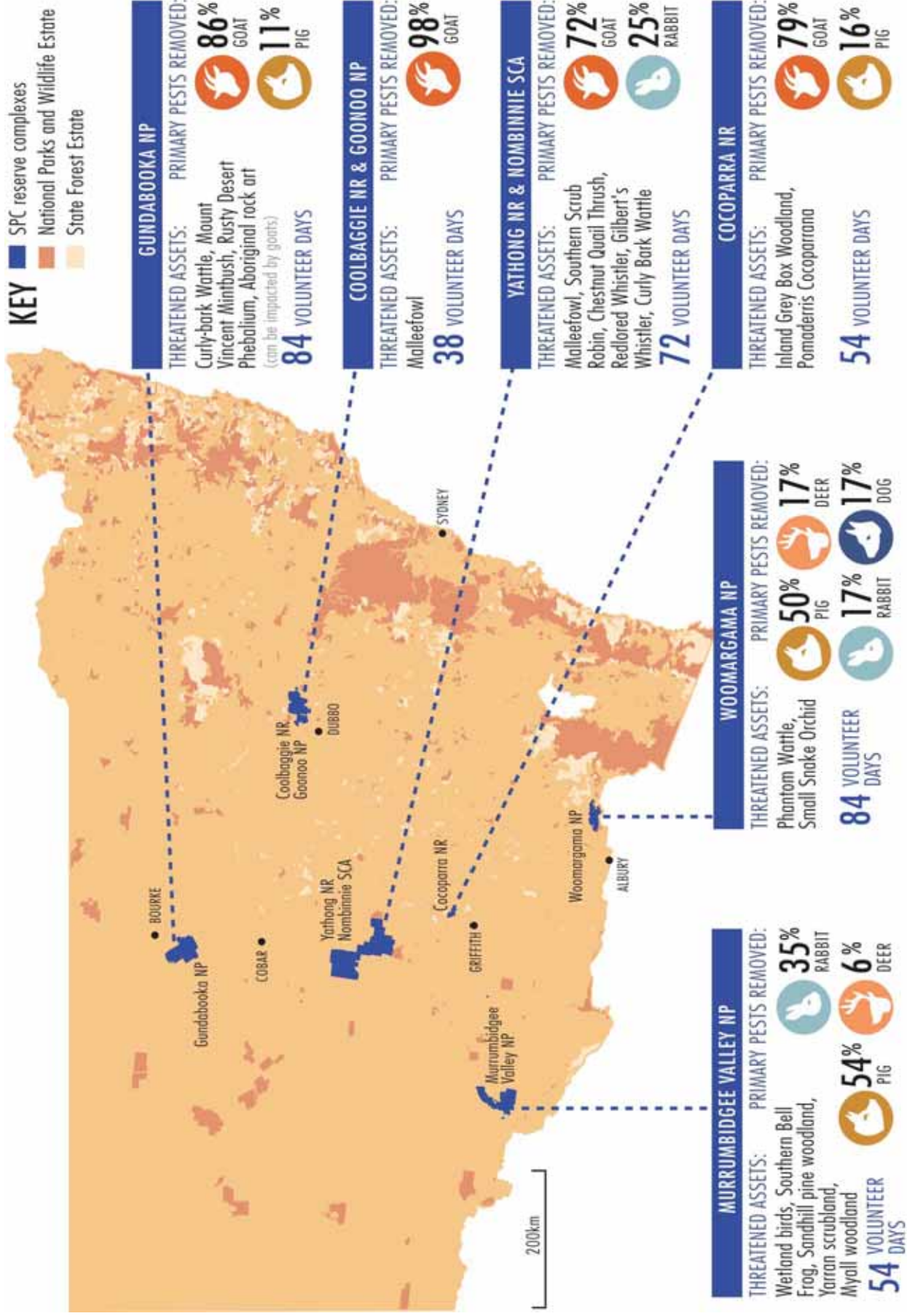


Figure 1: SPC reserves

2 Recommendations

SPC operations should be implemented where they are likely to have the greatest benefits relative to other options. As such, the Commission recommends that the SPC program only continue and be expanded on the condition that all of the following recommendations are implemented to maximise the benefits of the program.

1. Strengthen safety and risk protocols

The current safety and risk management steps remain in place to maintain volunteer safety and animal welfare standards and are complemented by the following additional measures:

- a. **Annual firearm accuracy tests** are conducted by all volunteers of the program, in line with current requirements for NPWS SPC staff. Opportunities to include moving target accuracy tests as part of volunteer testing should be explored.
- b. **A process allowing NPWS to request specific volunteers based on capability and best fit** for different operations be developed with SSAA NSW. Consideration should be given to volunteers' physical fitness and shooting capability to limit potential human and animal welfare concerns and maximise pest management benefit.
- c. **Review procedures** regarding park visitation, closure of entire parks and reserves, the quantity of signage, staffing ratios and pre and post operation incident or issues alerts, and modify as appropriate based on risk assessment.

2. Integrate pest management

All volunteer ground shooting operations be strategically integrated with other pest management activities and only undertaken when the following criteria are met:

- a. **Safety standards are maintained and strengthened in accordance with Recommendation 1.**
- b. **They are sequenced with other techniques and can further reduce pest numbers to a level that other techniques cannot**, in particular: where population densities are either low or have been sufficiently reduced through large knock-down pest management techniques; and/or alternate management techniques do not exist.
- c. **Pest type, densities and the threat they pose to threatened native species and ecological communities have been assessed** to identify where operations are suitable and can provide the most benefit.
- d. **Area accessibility**, vegetation density and topography are assessed in relation to suitability for effective ground-shooting.
- e. **Tools and methods that enhance effectiveness are used**, such as targeting nocturnal pests at night with night vision technology.
- f. **Size of shooting areas are adjusted** relative to pest animal type and population dynamics.
- g. **Operations are coordinated** with wider pest management control programs where possible.
- h. **Annual Pest Management Operation Site Plans** are regularly reviewed, updated and adaptively managed.

3. Centrally coordinate the SPC program

The SPC program be centrally coordinated by a small dedicated SPC staff that directs services to priority regions as required.

Central coordination will ensure a continued high level of risk management, a single point of contact for SSAA NSW volunteers, and that the program targets areas where supplementary ground-shooting is most beneficial.

The coordination should be implemented such that:

- a. **protection of at risk assets** is a focus of operations
- b. **SPC is sufficiently integrated** with other pest control techniques
- c. **costs of central coordination and management are minimised** to the degree possible while maintaining quality and safety
- d. **opportunities for SPC coordination staff to participate in other pest management programs** are identified and supported, subject to SPC priorities and capacity.

4. Provide new dedicated funding

New funds be allocated for the SPC program to ensure that the program maintains its high quality and safety standards, while also maintaining core funding for broader pest management. There should not be an expectation that the SPC program be funded from agency core budgets for pest management.

5. Develop and publish an SPC park selection prioritisation methodology

Parks and reserves across NSW be reviewed to determine their suitability for SPC program services.

Only parks and reserves that meet the following requirements should be eligible for SPC program services:

- a. **general assessment of their suitability for volunteer ground-shooting operations** based on safety and practicality
- b. **confirmation that they have met all the criteria outlined in Recommendation 2**, particularly that they have reached a point in the pest management cycle where SPC would be most beneficial.

All parks and reserves that meet the conditions outlined above should be ranked and prioritised based on a risk-based prioritisation methodology to determine which parks and reserves receive SPC program services.

The NPWS pest and weeds team and SPC program team should develop a prioritisation methodology based on asset protection and risk. In time, a similar prioritisation process should be expanded and applied across all pest management activities within all NPWS parks and reserves.

6. Continue evaluation of night operations

Night operations be monitored and evaluated by the Commission until June 2018 to further assess safety and effectiveness.

The short period in which night operations have been conducted (since March 2016), combined with the cancellation of a number of night operations due to poor weather, has resulted in limited available data. Early results indicate that these operations have been highly successful in targeting nocturnal pests and can be done safely, but these results should be confirmed. Subject to the findings of further monitoring, the Commission sees merit in including night shooting opportunities in any ongoing SPC program.

7. Expand communications strategy

The current communications strategy be maintained and integrated with other NPWS communications.

8. Conduct regular independent review

An independent review of the SPC program be conducted every four years, with the first review to be finalised by December 2020.

9. Establish outcome-based metrics supported by effective monitoring

NPWS establish a set of measurable and reportable pest management performance metrics, supported by robust, cost effective monitoring.

The performance metrics should be outcome-based and have clear alignment with legislated objectives. NPWS management should be assessed against these performance metrics and held accountable for delivering pest management outcomes. It is recommended that SPC monitoring be integrated into broader pest management monitoring and therefore, separate monitoring funds should not be required for ongoing SPC activities.

3 Overview

In 2013, the Minister for the Environment announced a three-year trial of supplementary pest control (hereafter referred to as the “SPC trial” or the “trial”) in NSW to remove pest animals including feral goats, pigs, foxes and rabbits. The SPC trial began in early 2014 in 12 national parks and reserves (six reserve complexes), covering an area of almost half-a-million hectares. **Figure 1** (see Executive Summary) provides an overview of the program activities and locations.

For the SPC trial, NPWS has partnered with volunteer shooters from Sporting Shooters Association of Australia NSW Branch (SSAA NSW) to help reduce the pest animals with an aim to manage and protect threatened species and ecological communities. These SSAA NSW volunteers work under the direct supervision of NPWS staff.

The SPC trial was implemented to allow for assessment of whether ground shooting using volunteers should be added to the existing suite of techniques to complement ongoing NPWS pest control programs.

Through a Terms of Reference, the Premier and the Minister for the Environment requested that the Commission evaluate the SPC trial and advise the NSW Government on progress to date, whether to proceed beyond the three-year trial period, and under what conditions.

The Terms of Reference is provided at Attachment 1. It requests that the Commission’s evaluation considers issues such as (but not limited to):

- the effectiveness of the trial program in contributing to the aims and objectives of existing NPWS pest control programs
- the efficiency of the trial program
- the social impacts of the trial.

3.1 Methodology

This report examines how the SPC trial has performed between January 2014 and December 2016. Drawing on a set of evaluation questions and methods developed specifically for the trial, the report examines the efficiency, effectiveness and social impacts of the trial and provides recommendations to Government about the future of the SPC program.

3.1.1 Evaluation questions

The Commission worked closely with stakeholders to design a robust evaluation framework, which is provided in Attachment 2. An Overview of the Evaluation Framework was submitted to the Minister for the Environment in August 2014, and is available online.

The framework provides a set of evaluation questions that were used to measure success against the four trial goals (see Attachment 2). The questions were designed to fulfil the Terms of Reference and reflect best practice in evaluation.

3.1.2 Evaluation methods

The Commission, together with key stakeholders, implemented a number of methods to evaluate the SPC trial including:

- Field observations:
 - Commission staff attended 34 percent of field operations conducted during the trial. This included at least one operation in each of the sites sampled in the document review.
- Commission staff recorded the following information of relevance to this report:
 - issues or concerns raised by staff and volunteers
 - operational issues and how they were dealt with
 - observations of safety or animal welfare issues.
- Document review: the Commission analysed:
 - all incidents logged
 - responses to the post operation surveys completed by NPWS staff
 - responses to the post operation surveys completed by SPC volunteers
 - responses to the SSAA NSW SPC volunteer surveys
 - total SPC trial and individual park costs.
- The Commission engaged First Person Consulting Pty Ltd to review the alignment of SPC operations with park and regional plans.
- Interviews, surveys and workshops with stakeholders:
 - The Commission conducted mid-trial and end of trial feedback workshops held with volunteers and NPWS staff.
 - The Commission conducted 10 interviews including all NPWS SPC staff and NPWS regional managers.
- Desktop research:
 - The Invasive Animals Cooperative Research Centre was commissioned to conduct independent research into ground shooting as a pest control technique.
 - In addition, the Commission carried out targeted desktop research into particular issues as needed.
 - The Commission engaged Roberts Evaluation Pty Ltd and First Person Consulting Pty Ltd to conduct interviews with park neighbours, relevant community and Aboriginal groups in July 2015 and October 2016. These interviews sought stakeholder's views on the social impacts of the trial.
- Technical review:
 - The NPWS ecological and operational monitoring document (*Interim Evaluation Report*, 2016) and SPC ecological data were reviewed and analysed by an independent vertebrate pest expert. The reviewer:
 - Looked at whether the ecological and operational monitoring framework was appropriate for the SPC trial.
 - Identified missing elements and recommended opportunities for improvement.
 - Assessed monitoring data and provided analysis of the effectiveness and efficiency of the program from an ecological perspective.

4 Refining the SPC Program

4.1 Maintain human safety and animal welfare

Successful management of human safety and animal welfare are strengths of the SPC trial. The SPC trial has demonstrated that volunteer ground shooting can be done safely and humanely when sufficient risk management, supervision and planning is undertaken. Current safety and animal welfare requirements have been rigorously applied and there have been no major safety incidents in the first 18 months of the trial.

NPWS staff rated more than 90 percent of SPC volunteers as good or very good for firearm safety and other health and safety procedures, with no poor ratings recorded. Some 80 percent of SPC volunteers scored a good or very good rating for shot placement (one measure of animal welfare), with no poor ratings recorded.

In addition, evidence from Commission field observations indicates that human safety protocols have been strictly adhered to, with lengthy discussions and demonstrations at pre-operation briefings. Pre-briefings also included detailed presentations on gun handling and storage, animal welfare and shot placement.

SPC volunteers expressed positive feedback about the human safety aspects of the trial through post operation surveys. All volunteers surveyed agreed that SPC operations were consistently implemented in accordance with required animal welfare standards. Similarly, all volunteers surveyed reported that they felt very or extremely confident in the ability of NPWS staff to conduct operations safely.

4.1.1 Areas for improvement

The evaluation also identified ways to further enhance assurance of safety and welfare. Feedback from volunteers and park staff indicates that volunteers are not suitable for all ground shooting operations. Certain operations will be safer and/or more efficient if carried out by NPWS staff or contractors, depending upon factors such as terrain, location and pest density.

Interviews with NPWS staff, feedback from volunteers and observations by the Commission in the field indicate that certain terrain and vegetation densities were not suitable to certain volunteers. Further, as identified in the volunteer appraisals, some volunteers could improve their shooting accuracy, especially when shooting from vehicles. NPWS SPC staff currently complete annual firearm accuracy testing whereas volunteers undergo a one-time test when registering for the trial. NPWS staff and volunteers noted:

"The fitness levels of the volunteers needs to suit the field conditions" – NPWS staff

"SPC shooters need to be assessed on fitness and shooting skills more thoroughly" – SPC volunteer

Through interviews with NPWS staff, a review of safety protocols, and observations during site visits the Commission identified several internal processes that could be streamlined to improve efficiency including:

- **Park closures and signage requirements** - Extensive signage and entire park closures are required for the trial operations. Public notice is also required on the NPWS website four weeks in advance of an operation and operations are advertised in local newspapers one week prior to being carried out. Given the size of many reserves, there is significant time and staff cost associated with these efforts. At times, they also limit the flexibility with which operations can be conducted or changed due to weather or other external factors. This can be a major constraint to delivering effective pest programs. These procedures should be reviewed and aligned with requirements for similar operations such as aerial shooting, trapping and ground baiting to the degree appropriate based on risk.

- **Incident or Issues Alert** – Staff are required to provide an ‘Incident or Issues Alert’ about SPC operations to the Office of the Minister for Environment on the Monday before each operation and on the Monday following the completion of each operation. The Commission believes this is unnecessary if SPC operations were to continue and should only be required in the event of a major safety, animal welfare or other incident.
- **Staffing ratios** – Every effort should continue to be made to minimise the staff required at each operation based on risk. Staffing ratios have decreased since the commencement of the trial and should continue to be adaptively managed based on operational requirements and risk assessment.
- **Lead times** - At present a minimum of four weeks’ public notice is required prior to operations. At times, this requirement limits the flexibility with which operations can be conducted. This can be a major constraint to delivery of effective pest programs. As such, the Commission recommends that this process be reviewed and assessed on a risk basis.

Based on these findings the Commission’s evaluation has identified ways to further enhance assurance of safety and welfare.

Recommendation: The current safety and risk management steps remain in place to maintain volunteer safety and animal welfare standards and are complemented by the following additional measures:

- a. **Annual firearm accuracy tests** are conducted by all volunteers of the program, in line with current requirements for NPWS SPC staff. Opportunities to include moving target accuracy tests as part of volunteer testing should be explored.
- b. **A process allowing NPWS to request specific volunteers based on capability and best fit** for different operations be developed with SSAA NSW. Consideration should be given to volunteers’ physical fitness and shooting capability to limit potential human and animal welfare concerns and maximise pest management benefit.
- c. **Review procedures** regarding park visitation, closure of entire parks and reserves, the quantity of signage, staffing ratios and pre and post operation incident or issues alerts, and modify as appropriate based on risk assessment.

4.2 Strengthen integrated pest management

Pest management is considered to be most effective when it combines an integrated set of complementary tools and techniques carried out in a strategic manner. The Commission has sought to evaluate whether ground shooting using volunteers can support the toolkit of available pest control techniques and whether SPC operations can legitimately complement primary control techniques to increase the overall effectiveness of the NPWS pest management programs. The Supplementary pest control trial interim evaluation report¹ discussed early evidence of success in limited circumstances. It further indicated that the Commission would focus during the remainder of the trial on identification of the circumstances where SPC can provide maximum value to NPWS’ pest management programs.

The Commission engaged the Invasive Animals CRC to conduct a systematic literature review of ground-based shooting to inform the circumstances in which ground shooting operations are most efficient and likely to improve pest management outcomes. The report (Bengsen (2016), IA CRC, see Attachment 3) indicates that ground shooting can make an important contribution to pest management. However, shooting alone is often not sufficient, or is prohibitively inefficient, to achieve desired outcomes. The review notes that ground-based shooting is rarely, if ever, a cheap

¹Natural Resources Commission (2016), *Supplementary Pest Control, Interim Evaluation*.

and easy method for reducing pest impacts or over abundance. As such, it should be implemented strategically where it is likely to have the most benefit. The review notes that opportunistic shooting of pests outside of an integrated pest management approach can have a detrimental impact on operational effectiveness.

Figure 2 outlines key considerations that should be taken into account when planning an SPC operation to maximise outcomes. It is important that all of these factors are considered in planning operations.

Ground shooting can provide high value pest management outcomes when used to target populations that other techniques cannot. For example, ground-shooting can target populations in hard to reach areas unsuitable for aerial shooting and night shooting can be highly effective for targeting nocturnal, bait-shy animals. The most successful ground shooting operations are part of a broader population management strategy developed through careful examination of the options to determine what type of shooting operation is likely to be most useful and that integrates ground shooting with other control methods. Effective programs also establish and monitor meaningful objectives and ensure that operations are sufficiently resourced to meet and maintain those objectives.

In order to ensure that SPC operations are as effective as possible, ground shooting operations should be designed consistent with the findings above.

4.2.1 Improved pest management in SPC trial

The SPC trial was designed and executed consistent with many of the findings of the literature review. NPWS took efforts to integrate the SPC trial into existing pest management activities, resulting in improved strategic pest management. Improved management has principally resulted from professional centralised management of the SPC trial, the planning required for SPC operations and the high animal and human welfare and safety measures in place. The ongoing independent spotlight being placed on the SPC trial has also helped to drive focus on integration. The extent of improvement varied between parks. Additionally, the monitoring and evaluation required for the trial improved regional NPWS staff knowledge of pest issues and how to target specific pests.

The Commission engaged First Person Consulting to review the strategic alignment of operations (see Attachment 4). Their assessment indicates that SPC has been well aligned with, and integrated into, existing NPWS pest management programs, complies with the legislation and aligns with Government priorities.

The planning requirements for SPC have prompted regional managers to regularly review and assess the strategy behind management decisions. Interviews with staff indicate that the regular review of strategy and a focus on outcomes, as opposed to outputs, has started to create a cultural change within parks of NPWS. Whilst this is only at an early stage, an integrated, outcomes-focused approach to pest management has the potential to continue to improve overall NPWS pest management activities.

Each SPC complex included in the trial has three documents that guide the implementation of the trial: a Regional Pest Management Strategy (RPMS); Pest Management Site Plan (PMSPs); and SPC Shooting Operation Plan. Evidence from these documents indicates that shooting activities in SPC reserves are generally strategically aligned with other pest control activities undertaken by NPWS and neighbours. Aims and objectives are generally aligned throughout the NPWS strategic planning documents. A more detailed discussion of alignment is provided in Section 5.3.

KEY CONSIDERATIONS FOR SUCCESSFUL GROUND SHOOTING OPERATIONS

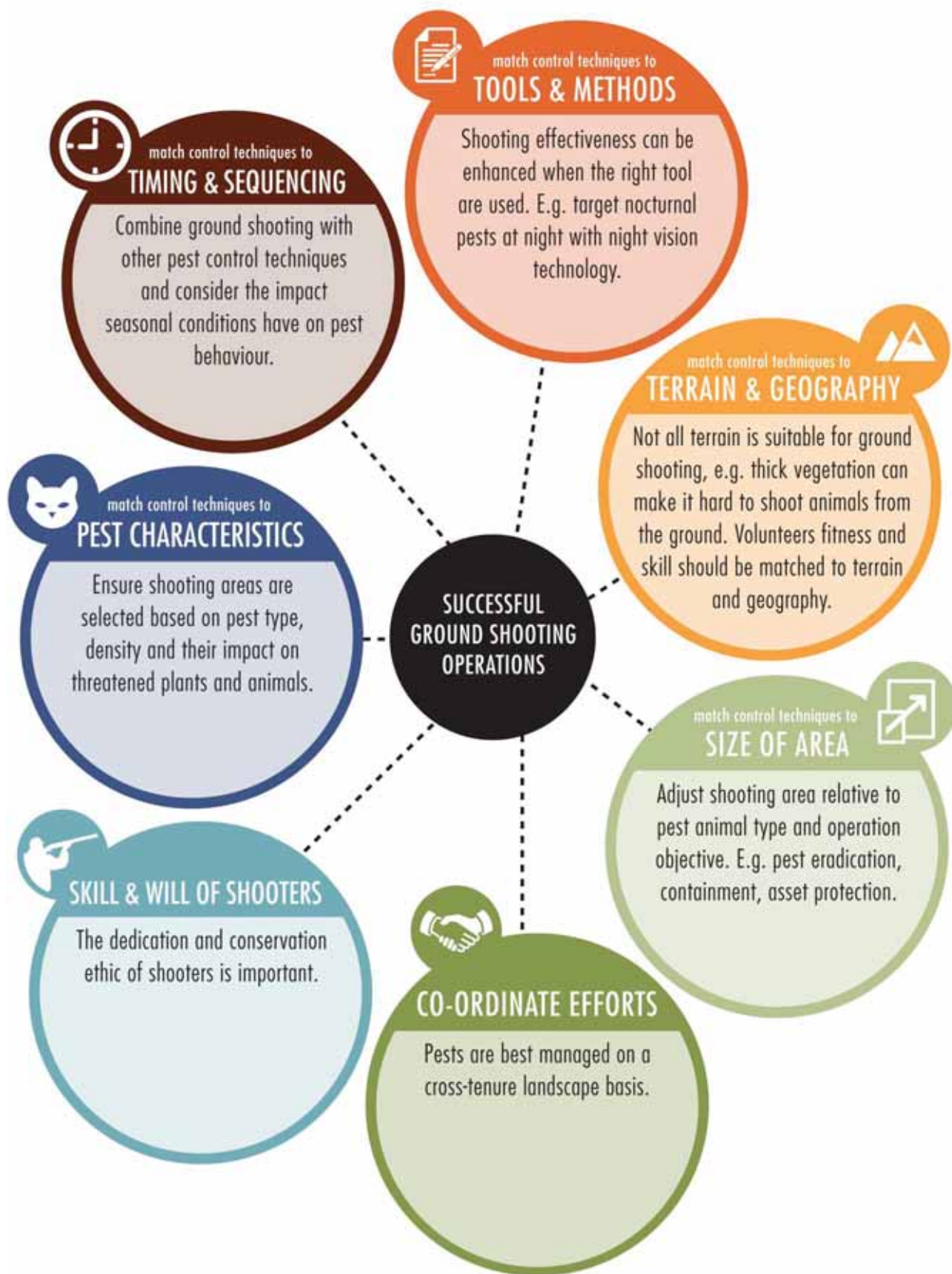


Figure 2: Key considerations for planning successful ground shooting operations

Review indicates that operational planning documents did seek to integrate ground-shooting with other primary pest management techniques such as aerial and ground baiting, trapping and mustering. Planning for the shoots took into consideration key issues such as pest characteristics, terrain and the size of the operational area. It is evident from interviews with both NPWS SPC staff and volunteers that the involvement of SSAA NSW in helping to select qualified and dedicated volunteer shooters was a strong contributing factor to the program's success. There is room to further improve coordination of pest management activities with other landholders.

Data clearly shows that the SPC trial removed a number of animals from various parks, which it can be safely assumed would not have been removed without the program. It is also apparent from field observations and interviews with volunteers and NPWS SPC staff that operations became more efficient over time with better targeted operations and the use of new technology such as night vision. However, due to limitations of ecological monitoring, the Commission is not able to conclude with confidence that integration and alignment demonstrated by the SPC trial delivered improved ecological outcomes.

For the SPC trial to deliver meaningful and lasting pest management outcomes it relies on other primary pest management controls being conducted with the requisite level of intensity for ground shooting to deliver maximum benefit. Examples from the SPC trial, such as the improved management of goats through mustering at the Central Mallee complex, followed by ground shooting, and the use of aerial operations to target pigs at the Yanga complex, demonstrate that the program did combine techniques to deliver improved animal removal. However, it is not possible to determine if the intensity of these activities were sufficient to deliver lasting outcomes. The evaluation indicates that budgetary constraints and the varying degree of focus on integrated pest management across the different reserves may impact on the NPWS ability to consistently prepare for effective ground shooting operations.

4.2.2 Areas for improvement

Areas for continued improvement include more frequent review of the Pest Management Site Plans and additional focus on coordination of pest management with neighbours. There is little evidence that Pest Management Site Plans have been updated since the Commission's 2016 *Interim Evaluation* with any substantial new information relating to planned pest control operations or relevant strategic information. To be most effective these plans should be routinely reviewed and updated.

The evaluation indicates that there has been some improvement in coordination with neighbours, but there is room for further improvements in this regard. Surveys of SPC park and reserve neighbours demonstrate varying opinions regarding whether the changes in pest management made during the SPC trial impacted on coordination of their pest management activities with park activities. Almost half of survey respondents (45 percent) indicated that the SPC trial had not changed the way that NPWS, Local Land Services and landholders coordinate pest management and 22 percent were unsure.

Recommendation: All volunteer ground shooting operations be strategically integrated with other pest management activities and only undertaken when the following criteria are met:

- a. **Safety standards are maintained and strengthened in accordance with Recommendation 1.**
- b. **They are sequenced with other techniques and can further reduce pest numbers to a level that other techniques cannot**, in particular: where population densities are either low or have been sufficiently reduced through large knock-down pest management techniques; and/or alternate management techniques do not exist.
- c. **Pest type, densities and the threat they pose to threatened native species and ecological communities have been assessed** to identify where operations are suitable and can provide the most benefit.
- d. **Area accessibility**, vegetation density and topography are assessed in relation to suitability for effective ground-shooting.
- e. **Tools and methods that enhance effectiveness are used**, such as targeting nocturnal pests at night with night vision technology.
- f. **Size of shooting areas are adjusted** relative to pest animal type and population dynamics.
- g. **Operations are coordinated** with wider pest management control programs where possible.
- h. **Annual Pest Management Operation Site Plans** are regularly reviewed, updated and adaptively managed.

4.3 Enhance program benefits

4.3.1 Ecological outcomes

The SPC trial was designed to complement existing NPWS vertebrate pest control programs in minimising the impact of pest animals on threatened species and ecological communities. Ecological monitoring was intended to determine whether the SPC trial was meeting this objective.

There are a number of challenges in monitoring the recovery of threatened species impacted by pest animals: the low abundance and variable distribution of threatened species; their slow recovery time; and difficulty in differentiating impacts from other factors.² The ecological and operational monitoring program for the SPC trial therefore includes measurement of pest species abundance and targeted monitoring of particular threatened fauna and native vegetation known to be at risk from pest animals. It also draws on existing monitoring programs, such as those in place for Malleefowl and FoxTAP programs.

The SPC trial's monitoring program suffers from a lack of experimental controls (areas with no pest control) against which the results can be compared. The Commission raised this in its preliminary and interim evaluations. Although not the original intent of the monitoring program, SPC trial monitoring is establishing baseline data for threatened species in the various reserves, which if used appropriately may be of value for monitoring the outcomes of future pest management activities.

In some instances, data does suggest that target animal populations have been effected by pest management in the reserves. However, due to the lack of control sites, the data cannot differentiate between impacts from SPC and other pest management activities. It should also be noted that the

² NSW Office of Environment and Heritage (2016), *Supplementary Pest Control Trial 2014 – 2016: Ecological and Operational Monitoring*, version 1.1.

sample period of 36 months, and only 9 months for night operations, is not sufficient to draw definitive conclusions about the ecological benefits of the trial.

Despite the limitations of monitoring data, the improved integrated management and potential for ground-shooting to eliminate otherwise hard to target pest populations is likely to result in improved ecological outcomes over the medium to long-term. Monitoring SPC will continue to face the limitations described. Ongoing monitoring should focus on demonstration of outcomes, to the degree possible, and be planned taking into consideration the cost benefit of monitoring efforts.

In particular, metrics should take account of:

- changes arising from the SPC program in the population numbers of all targeted pest animal species
- extent to which changes in the pest population resulting from SPC contribute to broader pest management control programs
- changes in the condition and extent of priority threatened species and ecological communities targeted by the SPC program
- overall cost-effectiveness of the SPC for delivering priority conservation outcomes
- overall community and landowner engagement with the SPC program.

Recommendation: NPWS establish a set of measurable and reportable pest management performance metrics, supported by robust, cost effective monitoring.

The performance metrics should be outcome-based and have clear alignment with legislated objectives. NPWS management should be assessed against these performance metrics and held accountable for delivering pest management outcomes. It is recommended that SPC monitoring be integrated into broader pest management monitoring and therefore, separate monitoring funds should not be required for ongoing SPC activities.

4.3.2 Social benefits

The SPC trial has had positive social outcomes including improved communications with neighbours and volunteers, increased community awareness and support from Aboriginal and community groups. The trial has developed positive relationships between NPWS and SPC volunteers. This is evidenced by the responses in the field, post-operational surveys and various workshops.

Since the SPC trial began, volunteers have consistently provided overwhelmingly positive feedback on the quality of planning and execution, team work, safety, NPWS knowledge and expertise, communication and animal welfare. Post-operation volunteer surveys indicated that over 80 percent of volunteers felt their expectations of SPC were met or exceeded, with no volunteers feeling their expectations had not been met.

Regular contact with neighbours has resulted in an increase in support for the SPC trial as evidenced through surveys of park neighbours. The number of neighbours who oppose the use of qualified volunteers declined significantly from July 2015 to October 2016. This is in contrast to surveyed non-SPC parks where 31 percent opposed the use of qualified volunteers for ground shooting (**Figure 3**). Neighbours who opposed the trial raised concerns regarding safety, animal welfare, cost effectiveness and negative perceptions of what the trial entails.

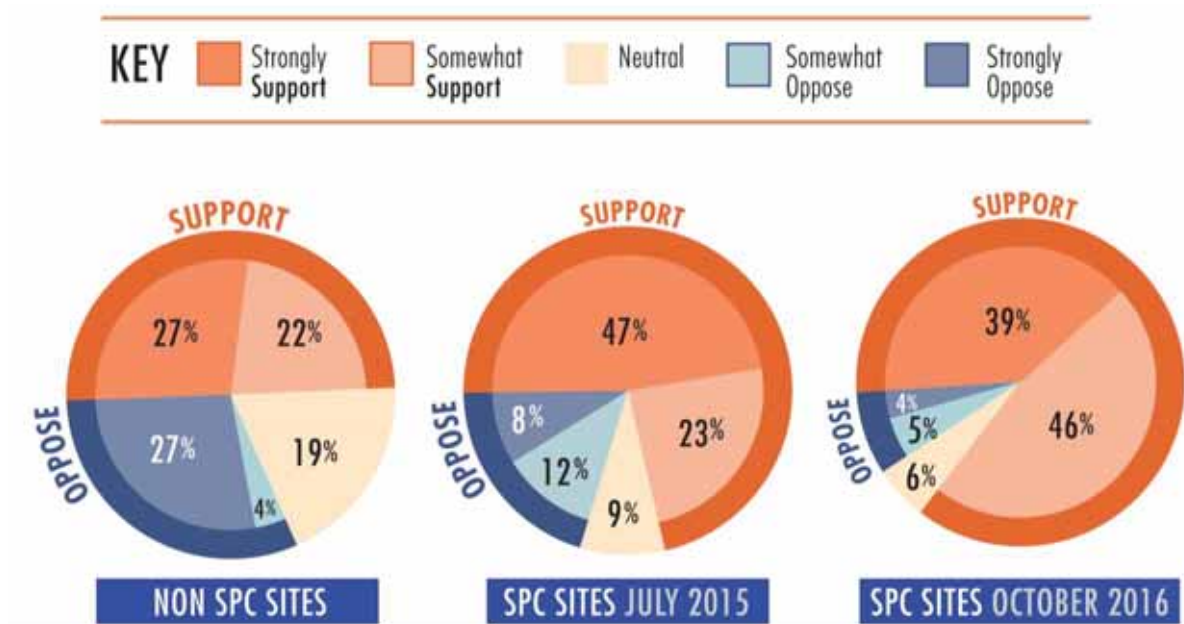


Figure 3: Neighbour survey results – support for SPC volunteers

Aboriginal and community groups have also responded positively to the SPC trial. Not all those interviewed were aware of the trial. However, of those who were familiar with it, many expressed support for its approach and intent. They noted both the importance of pest management and expressed support for using volunteers, provided they were appropriately vetted and supervised. Aboriginal group representatives also noted that they were satisfied with how cultural heritage sites had been managed as part of the trial (see Section 5.6 for more detailed analysis).

The results demonstrate that regular communication with neighbours can improve relationships as well as understanding of, and support for, programs such as the SPC trial. Communications about park activities requires continued management. NPWS should consider providing regular updates to neighbours, community and Aboriginal groups on the progress of pest management to share successes and promote positive pest outcomes. Adopting a strategic approach to communications and engagement would also assist in better coordination of pest management activities across all tenures.

Recommendation: The current communications strategy be maintained and integrated with other NPWS communications.

4.4 Refine SPC design

4.4.1 Central coordination

Based on field observations and interviews with NPWS staff and volunteers, the Commission is of the view that an important contributor to the success of the trial has been the professionalism of the NPWS staff and the centralised management of the trial.

Varying views were presented to the Commission during interviews about the degree of centralisation that is required for the SPC trial to be successful. NPWS SPC staff consistently support a centralised model, whilst feedback from NPWS regional management was generally more supportive of a regionally controlled model. It is apparent that the centralised model used for the trial was not normal practice for pest management within NPWS and did have some teething problems.

Despite varying views, it appears that the centralised model was an important component for successful delivery of the SPC trial. The centralised coordination and management:

- ensured consistency of approach with regard to human safety and animal welfare
- provided a singular point of contact for SSAA NSW and volunteers
- allowed for strategic coordination of operations within and across regions
- ensured SPC resources were allocated to SPC operations only.

Concerns raised regarding the centralised model included cost efficiency, tension between NPWS SPC and regional staff, and confused lines of reporting. Regional staff noted that some SPC staff were required to report to the SPC coordinator and their regional managers, which caused confusion and tension between the teams. This was accentuated due to some staff being embedded within regions while others were not. Some regional managers also noted that they had been led to believe that SPC staff could work on other regional priorities once SPC operations were completed. It appears in practice that there was little scope for SPC staff to assist with regional priorities, which led to some frustration between the teams. These issues appear to have caused internal tension at the time. However, feedback indicates most issues were ironed out over the period of the trial as it matured.

Should the SPC program continue, the Commission recommends that it be centrally coordinated by a small dedicated SPC staff that directs services to priority regions as required. Maintaining a small central team will allow these services to be delivered efficiently and reduce duplication of efforts at the regional level.

Recommendation: The SPC program be centrally coordinated by a small dedicated SPC staff that directs services to priority regions as required.

Central coordination will ensure a continued high level of risk management, a single point of contact for SSAA NSW volunteers, and that the program targets areas where supplementary ground-shooting is most beneficial.

The coordination should be implemented such that:

- a. protection of at risk assets is a focus of operations
- b. **SPC is sufficiently integrated** with other pest control techniques
- c. **costs of central coordination and management are minimised** to the degree possible while maintaining quality and safety
- d. opportunities for SPC coordination staff to participate in other pest management programs are identified and supported, subject to SPC priorities and capacity.

4.4.2 Dedicated funding

Another factor in the success of the SPC trial was the dedicated funding provided. The Commission's evaluation and its Pest Animal Review³ highlight that NPWS pest management and other park management activities are under resourced relative to need. Interviews with NPWS management staff indicated that if the SPC program were to continue and a dedicated source of funds was not allocated, then it is likely that little to no coordinated ground shooting operations would be conducted due to the perceived risk and effort involved. NPWS staff indicated that even where SPC might be effective and appropriate, funds would likely be directed to efforts more easily coordinated by, and familiar to, regional staff if possible. As one regional manager indicated with regard to support for the trial within the region:

"A lot of time and money is required to manage volunteers. If it is left to the regions then not much would happen. Regions are already stretched and new money would be needed."

³ Natural Resources Commission (2016), *Shared problem, Shared Solutions, State-wide review of pest animal management*.

Recommendation: New funds be allocated for the SPC program to ensure that the program maintains its high quality and safety standards, while also maintaining core funding for broader pest management. There should not be an expectation that the SPC program be funded from agency core budgets for pest management.

4.4.3 Improve site selection

In the 2014 evaluation of the SPC trial design, the Commission highlighted that the selection of SPC reserves may have an impact on the effectiveness and efficiency of the trial. The coordinated integration of pest management activities across tenures ensures the most effective and efficient pest management outcomes. The lack of cross tenure management has limited the ability of the SPC trial to deliver meaningful and lasting pest management outcomes. Furthermore, the trial has highlighted that the restriction to 12 reserves has reduced the ability to manage pests at the appropriate scale.

For instance, one regional manager noted:

"Being forced to use only one reserve makes it difficult to fully integrate. If you could integrate into the region it would make a big difference."

Given feedback received, and noting the importance of integrated pest management to meaningful outcomes, the Commission recommends that all parks and reserves across NSW be reviewed to determine their suitability for SPC operations.

Recommendation: Parks and reserves across NSW be reviewed to determine their suitability for SPC program services.

Only parks and reserves that meet the following requirements should be eligible for SPC program services:

- a. **general assessment of their suitability for volunteer ground-shooting operations** based on safety and practicality
- b. **confirmation that they have met all the criteria outlined in Recommendation 2**, particularly that they have reached a point in the pest management cycle where SPC would be most beneficial.

All parks and reserves that meet the conditions outlined above should be ranked and prioritised based on a risk-based prioritisation methodology to determine which parks and reserves receive SPC program services.

The NPWS pest and weeds team and SPC program team should develop a prioritisation methodology based on asset protection and risk. In time, a similar prioritisation process should be expanded and applied across all pest management activities within all NPWS parks and reserves.

4.5 Continue to improve cost effectiveness

The SPC trial has demonstrated ongoing improvements in efficiency and its continuation would leverage already sunk costs. Costs per planned operation have declined by around 58 percent since the commencement of the SPC trial. The total cost of the SPC trial from 2012/13 through 2016/17 was \$5.9 million, which represents an underspend of \$5.1 million from the original \$11 million allocated for the SPC trial.

As shown in **Figure 4** below, 'SPC staff costs' make up the largest portion of SPC expenditure. This value includes staff salaries, meals, accommodation, vehicle and incidentals with SPC staff salaries constituting the largest portion ('SPC staff cost' in **Figure 4** below).

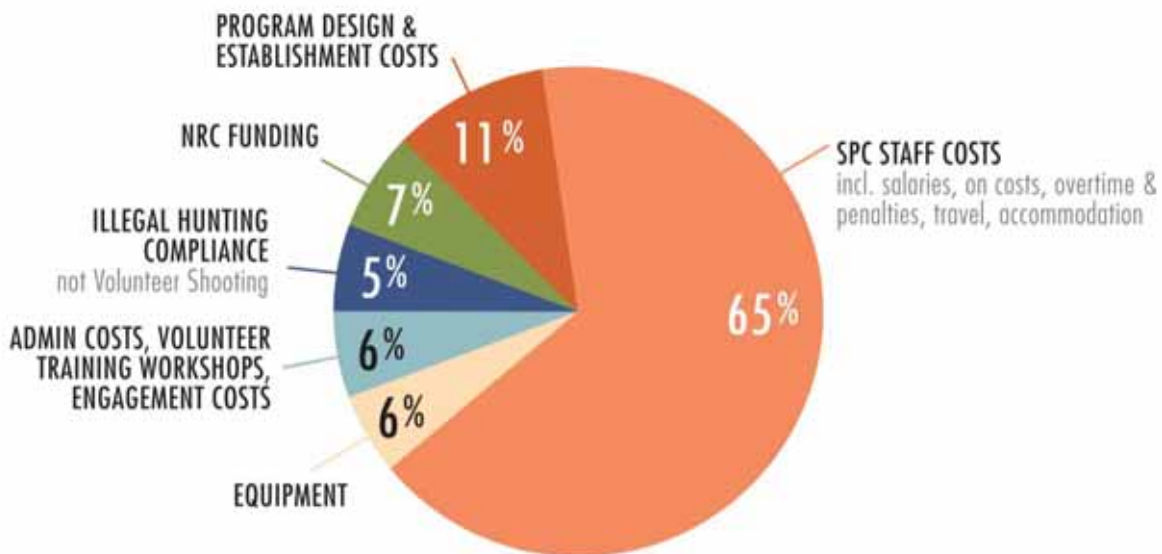


Figure 4: SPC total expenditure

Improvements in efficiency have been made through: improved planning, which has reduced the need for overtime; changes in staffing ratios; reduced use of access control staff at some complexes during operations; and improved meal and accommodation arrangements. As a result of these improvements in efficiency the average cost per operation (excluding monitoring) has declined significantly over the course of the SPC trial as shown in Figure 5:

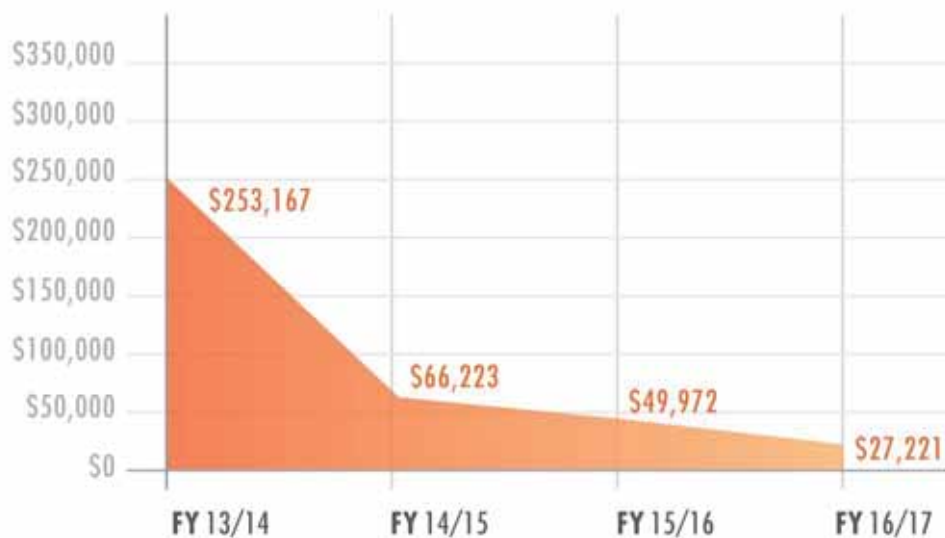
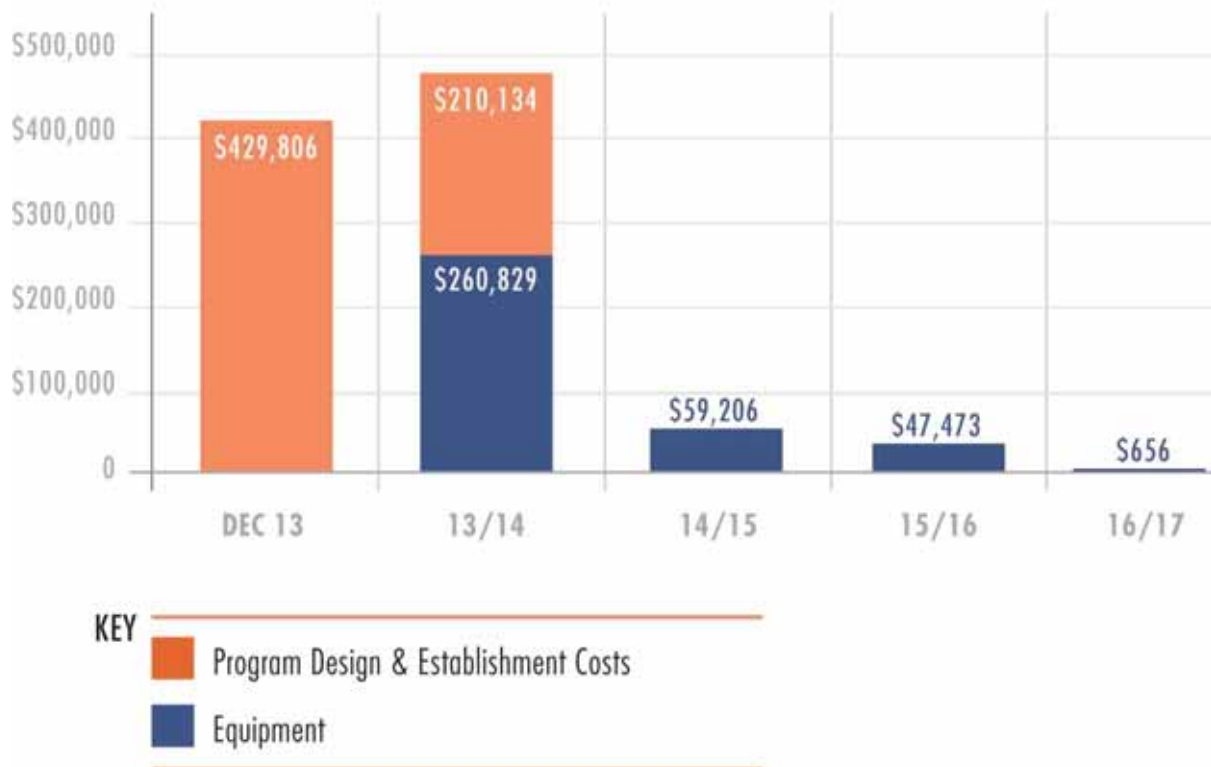


Figure 5: Average cost per planned operation

Establishment and program design costs totalled \$0.64 million, or around 11 percent of total program costs, which should not be reincurred should the program continue. In addition, a significant amount of equipment, including GPS trackers, field monitoring cameras and night vision equipment, was purchased to meet the trial's safety requirements and conduct night operations. The cost of this equipment totalled \$0.37 million. As equipment can be used for an extended period of time once purchased, these costs declined over time (Figure 6).



*note: 2016/17 is to December 2016 only.

Figure 6: Establishment costs - trial design and equipment

The Commission’s recommendations regarding integrated pest management, review of safety and communication procedures and central coordination should help support continued ongoing improvements in efficiency.

4.6 Modify and maintain monitoring and evaluation

The Commission’s interim report identified limitations in the monitoring that was conducted for this trial. In order to maintain cost effectiveness, monitoring and evaluation should be conducted such that resources are allocated as efficiently and effectively as possible. As discussed in Section 4.2, the Commission recommends that NPWS establish a set of measurable and reportable pest management performance metrics, supported by robust, cost effective monitoring. The performance metrics should be outcome-based and have clear alignment with legislated objectives. NPWS management should be assessed against these performance metrics and held accountable for delivering pest management outcomes.

4.6.1 Night operations

From March 2016 the Government adopted the Commission recommendation to include night-time shoots in SPC trial operations. The purpose of this change was to target species that are primarily nocturnal (feral cats, deer and foxes). Between February 2014 and December 2016, there were 29 daylight operations and 11 day/night operations (see Section 5.4, **Table 6**). Day/night operations were conducted in all reserves excluding the Yanga complex.

The short period in which night operations have been conducted (since March 2016), combined with the cancellation of a number of night operations due to poor weather, has resulted in limited available data. However, it is apparent from the data collected to date that operations were three times more likely to remove cats when shooting at night than during the day. This is also reflected in volunteer days, with 3.6 volunteer days required to remove a cat during a day/night versus 11.2 volunteer days to remove a cat during day operations. Importantly no animal welfare or safety incidents have occurred since night operations were incorporated into the trial.

Early results indicate that these operations have been successful in more efficiently targeting nocturnal pests and can be done safely, but these results should be confirmed. The Commission therefore recommends that night operations should continue to be monitored.

Recommendation: Night operations be monitored and evaluated by the Commission until June 2018 to further assess safety and effectiveness.

The short period in which night operations have been conducted (since March 2016), combined with the cancellation of a number of night operations due to poor weather, has resulted in limited available data. Early results indicate that these operations have been highly successful in targeting nocturnal pests and can be done safely, but these results should be confirmed. Subject to the findings of further monitoring, the Commission sees merit in including night shooting opportunities in any ongoing SPC program.

4.6.2 Value of independent oversight

The feedback provided during the evaluation highlighted that the independent oversight from the Commission facilitated greater professionalism and cooperation in the way the SPC trial has operated. This resulted in an improved focus on efficiency, effectiveness and continual improvement, all of which enhanced the prospects of achieving the program's outcomes. NPWS management indicated that having an external party review their trial has not only heightened the level of accountability, but also improved the quality of the trial.

Independent oversight will remain important given the maturity of the trial and the associated safety and animal welfare considerations. This is particularly true if the trial is expanded to additional parks and reserves.

Recommendation: An independent review of the SPC program be conducted every four years, with the first review to be finalised by December 2020.

5 Detailed Analysis

5.1 Safety and animal welfare

As previously noted, successful management of human safety and animal welfare concerns, two focus areas for NPWS staff when preparing and conducting operations in the field, are strengths of the SPC trial.

Analysis of safety and animal welfare included a review of:

- incident logs
- over 100 post operational volunteer appraisals and surveys
- interviews with all NPWS SPC staff and management, NPWS area managers and relevant staff that had SPC operations in their regions
- two workshops with SSAA NSW volunteers held in November 2015 and February 2017
- two surveys taken in July 2015 and October 2016 with SPC park neighbours, community and Aboriginal groups
- field observations by Commission staff who attended 34 percent of all operations.

Incident logs indicate that no major incidents occurred during the trial. Minor incidents included punctured vehicle tyres, jamming of firearms, poorly sighted firearms, fatigue, failure of some communications and vehicular collisions with small tree stumps. Field observations by Commission staff indicate that protocols were observed in all instances. Those firearms that were not performing were taken out of operation and adjusted where appropriate. Vehicular related incidents, such as a punctured tyre, are expected when operating in the SPC complexes and attended to onsite.

Multiple communications were used including UHF radio, mobile phone and satellite phone to ensure safety of participants. If one form of communications did not work then another was used with the satellite phone always available.

The Commission notes that fatigue constantly needs to be managed, particularly in hot weather, difficult terrain or when operating at night. Post operation reports indicate that where volunteers were seen to be fatigued they were either not permitted to participate until recovered, or remained at the operational headquarters. The Commission has included recommendations regarding enhanced assessment of volunteer fitness based on specific operational requirements.

NPWS staff rated more than 90 percent of SPC volunteers as good or very good for firearm safety and other health and safety procedures, with no poor ratings recorded. When evaluating animal welfare issues, assessments indicate some 80 percent of SPC volunteers scored a good or very good rating for shot placement (one measure of animal welfare), with no poor ratings recorded. The RSPCA also attended an operation in 2015 at Yathong NP and were satisfied with the animal welfare procedures and protocols that were followed.

5.1.1 Neighbour and community feedback

Survey results from neighbours, community and Aboriginal groups in July 2015 revealed only one comment relating to concerns of animal welfare and safety from neighbours. Members of the Gundabooka Joint Management Committee were positive about NPWS efforts, noting that there was a good level of communication to ensure the safety of the community.

Concerns raised in survey feedback in October 2016 were also minimal with two respondents (2 percent) citing concerns with animal welfare and six (7 percent) noting concerns with safety.

Six of the concerns raised were not specific to any particular SPC incident or operation and related to general concerns about shooting by volunteers. It was also noted that when these concerns were raised with NPWS, individuals were satisfied with the response they received.

One specific concern related to shots being fired within a kilometre of a home. However, NPWS indicated that these shots were most likely fired by trespassers on the reserve and not from an SPC operation. A separate animal welfare incident related to a goat found by a neighbour to be shot and injured but not killed. Each shot fired by an SPC volunteer is recorded by the NPWS SPC staff on a GPS device. While it is not possible to be definitive, it is unlikely that this animal was shot by a volunteer based on available evidence.

5.1.2 Feedback from participants in operations

Evidence from Commission field observations indicates that human safety protocols have been strictly adhered to. The Commission observed a strong commitment to safety and animal welfare in discussions and demonstrations at pre-operation briefings and during operations. Pre-briefings included detailed presentations on gun handling and storage, animal welfare and shot placement. Post operation volunteer appraisals indicate that those volunteers who were not meeting the protocols in the field were mentored and, on the rare occasion where necessary, stood down for the operation.

Post operation surveys with SPC volunteers provided positive feedback about the human safety aspects of the program. All volunteers surveyed noted that SPC operations were always implemented in accordance with required animal welfare standards. Similarly, all volunteers surveyed noted that they felt very or extremely confident in the ability of NPWS SPC staff to conduct operations safely throughout the trial. This was confirmed with volunteers at volunteer workshops in November 2015 and February 2017. Volunteers indicated that NPWS SPC staff maintained very high animal welfare and safety standards throughout the trial.

Example survey comments from volunteers included:

"All NPWS staff very knowledgeable, educational & kept firearms safety standards high. Animal welfare protocol always followed."

"... safety came first and was a high priority."

"Safety was paramount."

"Planning and execution of the trial was faultless."

"At all times I felt involved and valued as a volunteer, the planning and safety of the operation is exemplary."

"Overall, an extremely professional operation with very good observation of safety and animal welfare."

"The program is excellently run and very professional."

"A high level of concern for animal welfare was demonstrated by all involved."

5.1.3 Areas for improvement

Interviews with NPWS staff, feedback from volunteers and the Commission's field observations indicate that certain terrain and vegetation densities were not suitable to certain volunteers.

For example, NPWS SPC staff noted that some volunteers were not suited to operations which required long walks through rugged and steep terrain, such as in the range at Yathong and Gundabooka.

A substantial body of data was collected on volunteer performance. Overall, the quality of the volunteers was very high. However, the SPC trial was not designed to provide additional training to those volunteers who were identified as needing it. In addition, there was also no mechanism to identify and select volunteers who were suitable to perform certain operations based on skill and fitness required. Field operations, interviews and workshops have revealed that the ultimate success of an operation relies heavily on planning, highly trained NPWS SPC staff and the suitability of the volunteers that are on operations.

If volunteers are not selected based on the type of operation, then the outcomes of the operation are potentially impacted. Given this, the Commission is of the view that SSAA NSW and NPWS should work together to develop a formalised process whereby volunteers are placed on operations based on the skills required to complete the operation and the individual volunteers capabilities. In addition, should NPWS or a volunteer identify that they require further training then SSAA NSW should, in consultation with NPWS, develop a process and provide this training. In interviews, SSAA NSW representatives have indicated support in principle for such additional training and selection criteria. Feedback from volunteers also indicates that volunteers are dedicated and willing to put in the effort to qualify for the SPC trial. However, if they put this effort in they feel there needs to be a sufficient number of operations that they can participate in annually.

Further, as identified in the volunteer appraisals, some volunteers could improve their shooting accuracy, especially when shooting from vehicles. As **Figure 7** indicates, while most volunteers rated well, 18 percent of volunteers showed average or poor shot placement and marksmanship skills.

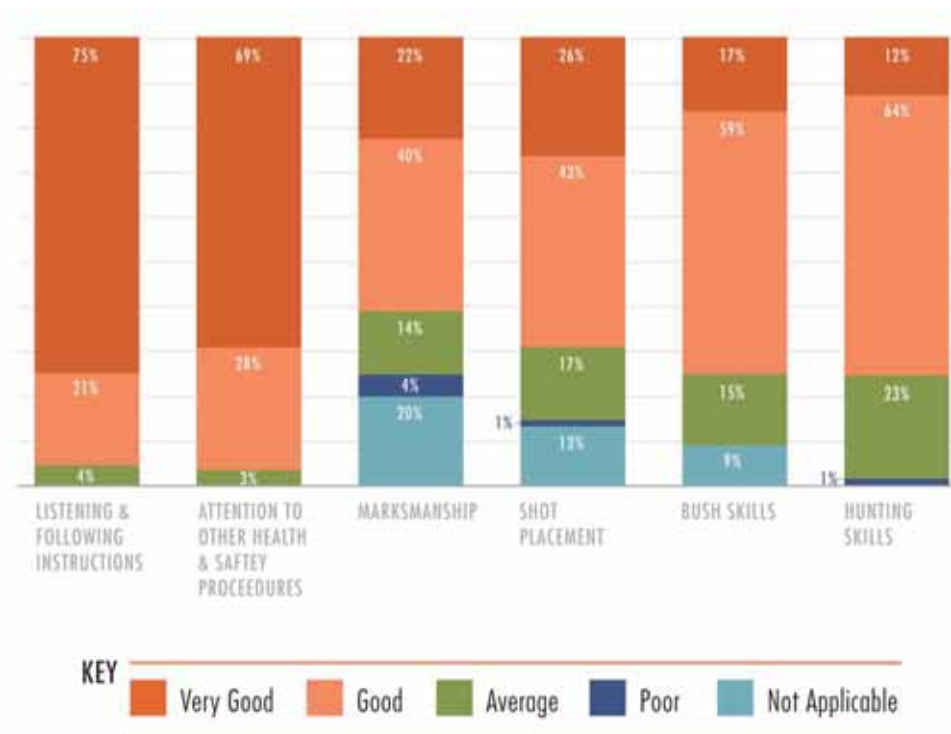


Figure 7: NPWS appraisals of SPC volunteers

Note: 'Marksmanship' refers to general handling of firearms. 'Shot placement' refers to the actual area on the animal where the shot lands. 'Not applicable' refers to instances where no shots were fired and marksmanship, shot placement and bush skills could not be assessed.

Through interviews with NPWS staff, a review of safety protocols, and observations during site visits the Commission identified several internal processes that could be streamlined to improve efficiency and effectiveness, including:

- **Park closures and signage requirements** - Extensive signage and entire park closures are required for the trial. Public notice is also required on the NPWS website four weeks in advance of an operation and advertised in local newspapers one week prior to an operation. Given the size of many reserves and that operations are only targeted in isolated park areas, the significant time and staff cost associated with these efforts may not be necessary to address risk. At times, they also limit the flexibility with which operations can be conducted or changed due to weather or other external factors. This can be a major constraint to delivering effective pest programs. These procedures should be simplified and aligned with requirements for similar operations such as aerial shooting, trapping and ground baiting as appropriate based on risk.
- **Incident or Issues Alert** – Staff are required to provide an ‘Incident or Issues Alert’ about SPC operations to the Office of the Minister for Environment on the Monday before each operation and on the Monday following the completion of each operation. The Commission believes this is unnecessary if SPC were to continue and should only be required in the event of a major safety, animal welfare or other incident consistent with current protocols.
- **Staffing ratios** – Staffing ratios have decreased since the commencement of the trial and should continue to be adaptively managed based on operational requirements and risk assessment. While there is a threshold-staffing ratio for operations that is determined by risk assessment, there would be merit in continuing to streamline the staff required for each operation as the program matures. This is the approach which has been taken with the SSAA Queensland Conservation and Wildlife Management and Queensland Parks and Wildlife Service partnership with ratios adjusted as the program matured. The Commission has also considered opportunities for NPWS SPC staff to participate as shooters in operations and considers that it is not appropriate at this time given the program maturity. However, this may become appropriate in certain circumstances in the future.
- **Lead times** - At present a minimum of four weeks’ public notice is required prior to operations. At times, this requirement limits the flexibility with which operations can be conducted. This can be a major constraint to delivery of effective pest programs. As such the Commission recommends that this requirement be revised on an as needs basis based on risk.

5.2 Effectiveness of ground shooting as a pest management technique

The SPC trial was designed to supplement other NPWS pest management operations to improve protection of threatened assets. The Commission engaged the Invasive Animals CRC to conduct a systematic literature review⁴ of ground-based shooting to inform the circumstances in which SPC operations are most likely to be efficient and improve pest management outcomes.

The literature review indicates that ground shooting can make an important contribution to pest management. However, shooting alone is often not sufficient or is prohibitively inefficient to achieve desired outcomes. The review also notes that ground-based shooting is rarely, if ever, a cheap and easy method for reducing pest impacts or over abundance. As such, it should be implemented strategically where it is likely to have the most additional benefit when combined with other control techniques.

The literature review yielded 36 journal articles. It involved a search and filter method to eliminate publication bias and focused on contemporary publications, with consideration of the Australian

⁴ Bengsen, A J (2016). *A systematic review of ground-based shooting for pest animal control*. PestSmart Toolkit publication, Invasive Animals Cooperative Research Centre, Canberra, Australia.

context. The search was limited to articles published after 1980 and only considered the first 50 articles returned by each Google scholar search to avoid publication bias.

The review identified several flaws and inconsistencies in the research articles and noted that conclusions were typically limited by the small sample size. However, overall the literature concludes that ground shooting can make important contributions to the management of pest animals. Of the 36 studies examined, 64 percent were quantitatively or qualitatively judged by the authors to have been effective in achieving useful reductions in damage to natural resources or the pest population.

5.2.1 Factors influencing success of ground shooting operations

Generally, ground shooting is most effective when integrated with well-planned and well-resourced pest management techniques. The literature review's systematic evaluation identified six recurring themes regarding specific contributors to the success of ground shooting operations most relevant to the SPC trial including;

- the use of efficient tools and methods,
- manageable area of operation,
- use of experienced or committed shooters,
- highly accessible areas of operations,
- strong conservation or ethic of unpaid shooters, and
- favourable environmental or topographical features.

Operations that used government or professional pest controllers were judged to be effective in at least 80 percent of cases surveyed, compared to operations that used unpaid shooters or commercial harvesters were found to be effective 50 percent or less of the time. This highlights the importance for SPC of ensuring that volunteer shooters are sufficiently experienced, properly trained and carefully selected. Augmenting volunteer capability through specific training when appropriate may also help to improve efficiency and effectiveness.

Shooting operations that were part of a broader pest management strategy were judged effective in 80 percent of cases in the literature review, compared with less than 60 percent of operations that did not integrate other control methods. As discussed in Section 5.3 the SPC operations were well integrated with other NPWS pest management activities.

The most frequently cited factor contributing to the success of shooting operations is the use of methods or tools that enhance the efficiency of shooters. Improving shooters' ability to humanely kill more animals per unit of time than they would typically be able to would increase the impact on population mortality. The Commission recommends that future SPC initiatives look to better leverage use of tools such as night vision technology to improve efficiency. Other technology, such as the use of drones to locate animals, should also be explored in an attempt to enhance efficiency.

Another frequently cited factor improving the effectiveness of shooting operations is the use of small areas of operation in which ground shooting can be concentrated to minimize population recovery. While most of the operations examined in the literature review have had to deal with larger areas of operation and permeable borders, studies show that dividing these areas, where possible, into smaller more manageable units improves efficiency and sustains focus and activity of shooters as pest animal population rates decline. Evidence from the SPC trial indicates that this approach was adopted across all SPC reserves. Operational plans and field observations indicate that SPC reserves were split into subsections that were subsequently divided into smaller operation areas. SPC volunteers would rotate between the smaller operation areas over the course

of an operation. This represents good practice and should have contributed to improved management outcomes.

Feedback from SSAA NSW volunteers and NPWS SPC staff at workshops and through surveys also indicates that the strong conservation ethic and commitment of the volunteers was a key strength of the program. These two aspects were also highlighted in the literature review as important contributors to successful ground shooting operations. The SPC trial includes a selection process in which volunteers are required to become qualified volunteers. This includes a firearms accuracy test, first aid training, attendance at briefing days and a willingness to commit to operations and travel to remote parts of NSW to attend operations. Evidence suggests that selecting volunteers with this level of commitment was a key factor in the operational and social success of the trial and these processes should be maintained if the program is to continue. Many volunteers expressed the view that an important aspect of the program for them was a sense that they were "giving back" and helping to make a difference.

Feedback from volunteers at workshops also indicated that the sharing of NPWS SPC staff knowledge with volunteers was highly valued and made the experience even more rewarding. Volunteers recognised there was real value in spending time with NPWS SPC staff who knew where pest animals were and were able to offer guidance and training during operations about how best to target pests. Volunteer's also highly valued the other information that NPWS SPC staff were able to share about Aboriginal heritage and threatened flora and fauna within the various SPC complexes. To this end the selection of NPWS SPC staff to conduct operations was a strong contributing factor to success of programs. This was acknowledged uniformly by volunteers in survey feedback and workshops. This transfer of knowledge and repeat participation by volunteers also contributed to improved efficiency throughout the trial. Furthermore, volunteers have repeatedly shown some interest in participating in pre and post operation work, such as putting and signage, and in monitoring of animals. Opportunities such as these should continue to be explored with a view to further enhance program efficiency.

5.2.2 Factors reducing the success of operations

Seven themes were identified as reducing the success of operations including

- a reduction in hunter efficiency as pest population declines
- insufficient coverage over space and time to counter immigration
- the presence of dense vegetation or inaccessible areas (refugia)
- selective harvesting
- low operational intensity relative to pest reproductive capacity
- minimal or no use of efficient tools and methods
- behavioural adaptation of pests due to repeated operations.

The most cited factor detracting from the success of shooting operations is the functional response of shooters to declining pest populations. This refers to the reduction in interest by recreational hunters and commercial shooters due to the high effort and low return when populations are low. This should not be a major factor for SPC operations, which are designed to target hard to reach and often scattered remaining populations. However, this could become an issue for the ongoing recruitment of volunteers for operations with the possibility of some volunteers choosing not to attend if populations are known to be low. Woomargama NP confronted this issue to some extent due to the low density of animals in this complex.

5.2.3 Impacts of ground shooting on pest management

In many cases a reduction in pest animal density does lead to a reduction in ecological impacts⁵; however this is not the case when this reduction is above the threshold density for certain pests. For example, two American studies identified the threshold density for deer at 10 deer per square kilometer to allow for the regeneration of vulnerable woody species⁶⁷. One study reporting a 75 percent reduction in deer density was considered to have been ineffective because deer densities stabilised above 10 per square kilometer.⁸

The literature also shows that the effectiveness of ground shooting can vary widely, from being highly effective to counterproductive. Success can depend on a careful selection of the most appropriate type of shooting operation, identification of meaningful objectives, allocation of adequate resources and integration with other techniques. At the planning level careful selection of the most appropriate type of shooting operation was identified as a key factor influencing the efficiency of the ground shooting operation. Measureable objectives were stated in 14 studies and most of these studies were judged to be either successful or were ongoing so results were unavailable.

5.3 Integration and alignment with existing pest management activities

Evidence from interviews with SPC staff and NPWS regional management, as well as review of pest management and SPC planning documentation, indicates that the SPC trial has led to improved strategic pest management in participating parks. NPWS staff noted the importance of independent evaluation in the SPC trial and the required planning requirements in driving improved integration of pest management.

The extent of improvements varied between parks. For example, a review of goat management at Yathong NR and Nombinnie NR & SCA has resulted in a more integrated management approach which uses mustering, trapping and shooting to control the population. A similar change was observed at Gundabooka NP & SA. Additionally, the monitoring and evaluation required for the program improved regional NPWS staff knowledge of pest issues and how to target specific pests. In contrast, integration of activities at some other parks, such as Goonoo was less clear, with coordination between SPC operations and other management actions not always as well aligned as it could have been.

While strategic management within parks and communication regarding pest management activities improved through the SPC trial, the Commission notes that there appears to have been limited impact on actual coordination with neighbours.

5.3.1 Strategic alignment of pest management operations

The Commission engaged First Person Consulting (see Attachment 4) to review the strategic alignment of operations. Their assessment indicated that SPC has been well aligned with, and integrated into, existing NPWS pest management programs, and it complies with the legislation and aligns with Government priorities.

⁵ Hone, J. (2007). *Wildlife Damage Control*. (CSIRO Publishing, Collingwood).

⁶ Mutze, G., Bird, P., Cooke, B., & Henzell, R. (2008). *Geographic and Seasonal Variation in the Impact of Rabbit Haemorrhagic Disease on European Rabbits, *Oryctolagus cuniculus*, and Rabbit Damage in Australia*. In P. Alves, N. Ferrand & K. Hacklander (eds) *Lagomorph Biology*, 279-293. (Springer, Berlin).

⁷ Bird, P., Mutze, G., Peacock, D., & Jennings, S. (2012). *Damage caused by low-density exotic herbivore populations: the impact of introduced European rabbits on marsupial herbivores and *Allocasuarina* and *Bursaria* seedling survival in Australian coastal shrubland*. *Biological Invasions* 14: 743-755.

⁸ Williams, S. C., Denicola, A. J., Almendinger, T., & Maddock, J. (2013). *Evaluation of organized hunting as a management technique for overabundant white-tailed deer in suburban landscapes*. *Wildlife Society Bulletin* 37: 137-145.

Each SPC complex has three documents that guide the implementation of the trial: a Regional Pest Management Strategy (RPMS); Pest Management Site Plan (PMSPs); and SPC Shooting Operation Plan (**Table 1**).

Table 1: Overview of pest management plans

Relevant Documentation	Description
OEH Regional Pest Management Strategies (RPMS)	RPMSs identify priority species for a range of pest management control measures in each OEH region, including the primary target species for the SPC trial in each site.
NSW National Parks and Wildlife Service - Pest Management Site Plans (PMSP)	The PMSPs for each region identify and document the highest priority pests for each SPC trial site, referencing the priority pest species in the respective RPMS.
OEH - SPC Shooting Operations Plan	Pest management shooting operation plans identify target species, and align aims and objectives of the shoot with PMSP and RMPs.

A review of these key documents indicates that shooting activities in SPC reserves are generally strategically aligned with other pest control activities done by NPWS and neighbours. Pest Management Site Plans detail how SPC shooting activities for each reserve complex are coordinated with other NPWS activities. They also describe wider involvement of neighbouring properties and community groups, as well as coordination with other agencies in pest management activities. However, survey results from park neighbours and discussions with Local Land Services indicate that not all regions actively go about coordinating programs at all possible opportunities.

The relevant Regional Pest Management Strategies identify priority species for a range of pest management control measures in each region, including the primary target species for the SPC trial in each site. The SPC shooting activities generally target species ranked in the Regional Pest Management Strategies as a “Critical” regional priority for management because of their impacts on threatened species. Key documents also indicate that shooting activities in SPC reserves are strategically aligned with other actions regarding threatened species. Importantly, the Regional Pest Management Strategies clearly note that the protection of these threatened species requires the effective control of the priority pest species for each site, confirming that the plans are based on identification of conservation assets that are at high risk.

The Pest Management Site Plans for each region identify and document the highest priority pests for each SPC trial site, referencing the priority pest species in the respective Regional Pest Management Strategies. Pest Management Site Plans for the trial sites generally identify the same threatened species as identified in their respective Regional Pest Management Strategies.

Aims and objectives are generally aligned throughout the SPC Shoot Plans, Pest Management Site Plans and Regional Pest Management Strategies. However, there are some instances of misalignment as detailed in **Table 2** below. Shoot Plans and Pest Management Site Plans document how their objectives are informed by overarching plans and strategies including their Regional Pest Management Strategies.

There is little evidence that Pest Management Site Plans have been updated since the Commission's 2016 *Interim Evaluation* with any substantial new information relating to planned pest control operations or relevant strategic information. The PMSPs for each region are intended to be updated every year. NPWS staff advised that the PMSPs were updated in November 2015 with some changes to operational information, but dates were not updated. However, First

Person's review of a sample of PMSPs indicated that only one of the PMSPs (for the Woomargama reserve) has been updated since the *Interim Evaluation* in 2016. The Commission considers that plans must be kept up to date so that on-ground operations can be adaptively managed, taking account of new pest information and conditions, to target the most effective areas and approaches.

Table 2: Inconsistencies between RPMS, PMSP and Shoot Plans for each SPC trial site.

SPC trial site	Inconsistencies between RPMS, PMSP and Shoot Plans
Central Mallee	In the Central Mallee PMSP, goats and foxes are listed as the primary target species for the SPC. The 2015 and 2016 SPC shoot plans list foxes as the primary target for all shoots, but they also list feral cats as a primary target for three operations in 2016 despite not being listed as a regional priority in the Western Rivers RPMS or a primary target species in the PMSP. Goats were only ever secondary targets in shoot plans.
Cocopara	Goats and pigs are listed as the primary target species for the SPC trial in the PMSP for the Cocopara region. This is reflected in the shoot plans, with pigs as the primary target in the March 2015 and June 2016 operations and goats as the primary target in the September 2016 operation. However, pigs are not listed as a management priority for the Cocopara site in the Western Rivers RPMS. Rabbits are listed as a critical priority for Cocopara in the RPMS; however this is not reflected in the PMSP.
Gundabooka	Of the primary target species for the Gundabooka site (goats, pigs, foxes and wild dogs), it is unclear from the PMSP which species were intended to be targeted through the SPC trial. Goats were identified as the primary target species in all six shoot plans available from 2015 and 2016, with pigs, foxes and wild dogs listed as secondary targets.
Woomargama	Of the primary target species for the Woomargama site (goats, pigs and rabbits), it is unclear from the PMSP which species were intended to be targeted through the SPC trial. Rabbits were listed as the primary target species for the May 2015 operation and pigs were listed as the primary target for the four SPC shooting operations in 2016. Foxes and wild dogs were listed as critical priority pests for the Woomargama site in the Southern Ranges RPMS, however dogs are not identified as primary target species in the PMSP or Shoot Plans.

5.3.2 Coordination with neighbours

As noted above, the pest planning documentation includes information regarding coordination with neighbours. However, interviews and surveys indicate that actual coordination varied between complexes and could be improved.

Survey results indicated that 32 percent of responding neighbours suggested that they had seen an improvement in pest management coordination over the course of the SPC trial, including better communication and working arrangements. This included interrelated changes to:

- Improved communication and education

NPWS [are] communicating better – communicating really well. We all seem to be working much better together. (Gundabooka survey respondent).

Better education about pest control, especially with dogs and pigs. (Woomargama survey respondent).

- Better working relationships and arrangements

We have started a local pest management group with Local Land Services. NPWS will join in the future. We are trying to coordinate pest management a bit more effectively. People are becoming a bit

more receptive of NPWS. In the past many people wanted nothing to do with them. (Central Mallee survey respondent).

- Greater coordination

There is a lot more talk out there amongst the agencies. They are all starting to get on the same page about what materials they are using and when they are using it. They are all starting to do the same thing now. (Central Mallee survey respondent).

I think people are working together more, doing it at the same time, which is reducing numbers of pest animals. (Central Mallee survey respondent).

Despite this, 92 percent reported that the SPC trial had not influenced the way that they manage pests on their own properties. Furthermore, almost half of survey respondents (45 percent) indicated that the SPC trial had not changed the way that NPWS, Local Land Services and landholders coordinate pest management and 22 percent were unsure. This suggests that while NPWS regularly communicated with park neighbours about SPC operations, this did not always or consistently translate into improved pest management across different land tenures.

5.4 Pests removed through SPC trial

It is important to remember that the focus on SPC is generally to target small remaining populations, once other control measures have reduced the size of the population. The Commission has collated field records on the number of animals removed through the SPC program. Whilst the number of animals removed is one output measure from the trial, it alone cannot provide a reliable measure of whether the SPC program has delivered on its ecological outcomes. Removal data should be reviewed in conjunction with other outcome measures such as the improvement of threatened native flora and fauna. However, even with such alignments it remains difficult to demonstrate that pest removals from the SPC program resulted in observed improvements to threatened species. It is likely that such improvements arise from the broader suite of pest control measures in place, interacting with outside favourable factors, such as good seasonal rainfall or changing land use practices.

Table 3 details the pests removed from the six SPC reserve complexes (12 SPC reserves). SPC volunteers removed 5,655 animals with goats accounting for 62 percent of all animals shot followed by rabbits (23 percent) and pigs (12 percent). Central Mallee followed by Yanga and Gundabooka reserves accounted for the majority of pest removals, while Woomargama National Park had the lowest number of pest animals removed.

Table 3: Number of animals removed in SPC reserves – February 2014 to November 2016

	Deer	Cat	Pig	Rabbit	Fox	Wild dog	Feral goat	Other
Central Mallee	24	39	71	936	8	0	2727	0
Cocopara	0	0	18	6	0	0	88	2
Goonoo	0	0	0	0	0	0	52	1
Gundabooka	0	5	76	10	6	0	599	0
Woomargama	1	0	3	1	0	1	0	0
Yanga	57	6	530	347	28	0	13	0
Total	82	50	698	1300	42	1	3479	3

The low number of pest animals removed at Woomargama National Park (six pest animals) corresponds with low numbers of pest herbivores detected by monitoring (motion-sensor cameras). Low pest herbivore density may be attributed to successful aerial shooting between 2008 and 2011 and the reserve's location at the end of a wildlife corridor. As previously noted, the low number of animals removed should not be viewed as a measure of the success of the program. It may indicate that this was the most appropriate location to employ ground shooting because other measures had already been exhausted and could not successfully target the remaining animals.

The rate of pest animal removal per hectare varied considerably across the reserves. Cocopara, the smallest of the target areas, represented the highest number of animals removed relative to reserve size, with one pest animal removed every 42 hectares on average. This is in contrast to the second smallest reserve area, Woomargama, where one pest animal was removed every 4,037 hectares on average (Table 4).

Table 4: Pests removed per hectare in six SPC reserves

	Pests removed	Complex area (ha.)	Pests removed/ ha.
Central Mallee	3,805	235,268	62
Cocopara	114	4,778	42
Goonoo	35	65,105	1,860
Gundabooka	696	89,484	129
Woomargama	6	24,224	4,037
Yanga	981	82,862	84
Total / average	5,655	501,721	89

Table 5 provides a summary of the number and type of animals removed through the SPC trial. Each operation had one to two primary target species, with the majority of operations targeting goats (41 percent) and pigs (28 percent). The proportion of primary target species removed relative to total pest animals removed ranged from less than one percent (primary target was the fox) to 100 percent (fox and goat were primary targets). This range indicates that during operations a number of non-primary target pest species were also eradicated.

Table 5: Summary of primary targets pests removed

Primary target species	Number of operations	Number of primary target species removed	Total number of pest animals removed during operation	Percentage pests removed that were primary target species
Fox	3	7	852	<1
Fox, goat	3	18	18	100
Goat	16	1,396	1,664	84
Goat, fox	3	1,399	2,126	66
Pig	11	268	373	72
Pig, rabbit	4	568	622	91
Total	40	3,656	5,655	

Achievements of the SPC trial suggest that the most positive results occur when SPC is combined with other pest management activities such as mustering. For example, there is evidence of improved management of feral goats in the open plain areas of Gundabooka and Central Mallee. In these areas, mustering, water point trapping and ground shooting have been used to manage the pest animal. Monitoring of areas in Gundabooka where these management practices were implemented observed a 68 percent decline per year in goat activity (based on goat faecal pellet counts). In open areas of Central Mallee where contract mustering occurred, there was an 80 percent decrease in goats observed during direct counts. There has been an observed movement of goats into the hard to reach range areas however. Ground shooting following mustering provides an opportunity to target goats that are not manageable through mustering and to target those goats who scatter into range areas.

5.4.1 Other factors affecting animal removals

Several factors in addition to pest population, reserve size and species targeted affect the number of animals encountered and removed. These include for instance, weather, environmental changes, terrain and accessibility, sequencing of other pest management techniques and the degree of pest management coordination across park and non-park borders (See integrated management, Section 4.2 for further detail). The case study below outlines a particular example of how environmental flows impact pest populations.

Case study: Yanga National Park pig population

External factors play a major role in managing certain pest species. For example, the proportion of feral pigs removed from the Yanga complex compared to other areas is likely associated with environmental water flows, which have a range of ecological benefits, but also support the pest animal. The February 2016 SPC operation followed a major environmental water event that had reached Yanga National Park in November 2015. This operation achieved the greatest number of pigs removed from this area under an SPC trial operation (201 animals compared to an average of 65.8 from the five previous operations in the Yanga complex).

5.4.2 Night operations

From March 2016, the government adopted the Commission recommendation to include night-time shoots in SPC trial operations. The purpose was to target species that are primarily nocturnal (rabbit, feral cats, deer, wild dogs and foxes). Between February 2014 and December 2016, there were 29 daylight operations and 11 day/night operations (see **Table 6**). Day/night operations were conducted in all reserves excluding the Yanga complex.

There is currently insufficient data to draw strong conclusions about the effectiveness of night-time shooting. Data collected to date indicates that operations can be conducted safely, with no major safety incidents reported. Operations were three times more likely to remove cats during night-time operations than during the day. This is also reflected in volunteer days, with 3.6 volunteer days required to remove a cat during a day/night versus 11.2 volunteer days to remove a cat during day operations **Table 7**. The data does not reveal statistically significant different results for the removal of rabbits, foxes, wild dogs or deer under night operations at this stage. However, it can be reasonably assumed with more operations this will change.

Feedback from NPWS SPC staff and volunteers indicated that night vision technology used during night operations has enhanced animal welfare outcomes with the ability to quickly confirm that individual animals have been removed. Volunteers also consistently report a view that they are able to see considerably more animals using the latest night vision technology, improving their efficiency.

Additional evaluation of night-time shoots is recommended in order to further assess their safety and efficacy.

Table 6: SPC pest animal operations by reserve complex

Area	Size (hectares)	Day-time operation	Day/night operation	Total
Central Mallee	235,268	3	2	5
Cocopara	4,778	8	1	9
Goonoo	65,105	3	2	5
Gundabooka	89,484	3	4	7
Woomargama	24,224	6	2	8
Yanga	82,862	6		6
Total	501,721	29	11	40

Table 7: Cats removed – SPC day and day/night operations

Operation	Number	Total volunteer days	Total feral cats removed	Volunteer days per feral cat removed
Day	29	269	24	11.2
Day/night	11	94	26	3.6

5.5 Ecological outcomes

In order to determine if ecological objectives are being achieved, threatened species recovery and vertebrate pest abundance need to be monitored. Section 4 highlighted several limitations of the ecological monitoring for the SPC trial including the short time period of the trial (relative to ecological changes), the lack of baseline data, lack of control sites and limitations specific to the monitoring methodology.

It should be noted that ecological monitoring is complex and can be extremely costly. NPWS used a number of tools to conduct monitoring including the use of pellet counts and day and night transects, motion-sensor cameras, and browse monitoring. A large proportion of NPWS SPC staff time was dedicated to monitoring pest abundance. However, the monitoring of threatened species recovery was limited and non-existent in some reserves.

Each SPC reserve has threatened species or endangered ecological communities that are being targeted for protection by ongoing vertebrate pest control programs. Ideally, measuring the responses of threatened species recovery to these pest control programs involves monitoring at treatment and nil-treatment sites. The NPWS *Ecological and Operation Monitoring* document (Attachment 6) was assessed by the Commission as part of its interim evaluation. The document presents methods to measure pest species abundance and threatened species condition and status, both before and after the management actions by NPWS staff and SPC volunteers.

A detailed discussion of the design limitations was included in the Commission's *Evaluation of trial design report* released in 2014 and *Interim Evaluation* February 2016. NPWS acknowledges many of these limitations in their *Ecological and Operational Monitoring* document. No experimental controls

(areas equivalent to the SPC sites with no pest control) were available. The monitoring provides weak evidence of the efficacy of the pest control without a before-and-after data set on the status of threatened species or communities. In general, the absence of random locations for some of the monitoring devices and systems means care must be taken in extrapolating results to the whole reserve complex, or to making inferences about the trial. In addition, it is unlikely that the monitoring methods are sensitive enough to discriminate between effects from general NPWS pest control efforts and any additional control achieved by the SPC trial.

Data collected since the *Interim Evaluation* has further evidenced the previous finding that the ecological monitoring to date has been useful in establishing baseline data of pest species and threatened assets for the various reserves, although this was not the original intention of the monitoring. In some instances, the data also suggests that target pest animal populations have been effected by controls in the reserves, although it is not possible to definitively attribute this specifically to the SPC trial. It should also be noted that the sample period of 36 months is not sufficient to draw strong conclusions about the ecological benefits of the program.

Despite these weaknesses in the monitoring, some data highlighted in case studies (Section 5.2.2) indicates that populations of certain species may be declining. Ecological monitoring is not sufficient to link this decline with a measureable reduction in impacts on threatened assets at this time. However, the intent of the program is that reducing the population of target pest species should improve the condition and extent of threatened ecological assets.

5.5.1 Monitoring results

Below is a summary of key outputs from the monitoring for select complexes. The outputs from the monitoring varied between parks and it is difficult to draw strong conclusion from this data for reasons mentioned above.

Table 8: Central Mallee

	Goat sightings per km	Pellet count	Goats removed by SPC	Goats mustered
Jun-14	6.6			
Jul-14				
Oct-14			633	
Nov-14	16.9			
Feb-15				
Mar-15	2.1	31		582
Apr-15			719	9932
Aug-15				
Oct-15	2.1	26	717	
Mar-16	1.6	26	612	
Jul-16			46	

Table 9: Camera sightings

		Gundabooka	Central Mallee	Woomargama
Pest type	Cat	0	0	4
	Fox	0	0	13
	Goat	2444	2083	0
	Pig	0	0	6
	Rabbit	0	3	8
	Wild Dog	0	0	3
Number of cameras		36	78	80

Table 10: Day and night transects – Central Mallee and Yanga

		Monitoring trip number				
		1	2	3	4	5
Cat	Central Mallee	35	75	44	29	18
	Yanga	8	5	2	19	9
Deer	Central Mallee	18	20	36	27	14
	Yanga	132	95		71	116
Fox	Central Mallee	39	36	40	5	13
	Yanga	32	41	23	57	47
Goat	Central Mallee	2108	5402	673	664	507
Pig	Central Mallee	33	32	17	28	3
	Yanga	154	283		60	174
Rabbit	Central Mallee	1486	1352	1695	264	413
	Yanga	139	100	37	80	24
Wild dog	Central Mallee					2

5.5.2 Case studies

The case studies below highlight some of the challenges in monitoring pest species abundance (and identifying impacts on abundance), and monitoring impacts to threatened species. Given these difficulties, the Commission recommends that NPWS continue to adapt monitoring practices with the aim of establishing a set of measurable and reportable pest management performance metrics, supported by robust, cost effective monitoring.

Monitoring of pest abundance case studies

Central Mallee Complex– Goats

Over the course of the program five operations, which primarily targeted goats and foxes, were conducted at the Central Mallee Complex with 3,805 pests removed through the SPC trial over this time, including 2,727 goats.

Goats were monitored as part of the SPC trial using different techniques in different parts of the complex because of differences in the density of vegetation. In the open central valley (low density of vegetation), goats were monitored by direct visual counts along driven transects. These counts were conducted at day and night on five separate occasions. There was an 80 percent decrease in the number of goats observed per km in the central valley after contract mustering (**Figure 8**), which commenced after trip 2 and removed 10,514 goats. In the denser areas of vegetation goats were monitored via motion triggered cameras set along roads. These cameras indicated that there was a very slight decline in goat numbers outside mustered areas.

Figure 8 clearly shows that goat numbers vary, with a sizable rise between trips 1 and 2, followed by mustering’s significant impact on numbers thereafter (decline in orange line). The SPC cull may have had an additional limited impact (decline in green bars between trips 3 and 5). However, other factors may have also affected goat populations over this period including the closure of water points, ground and aerial shooting, and variations in weather conditions.

The key limitations of this data are that:

1. It does not allow the Commission to draw any strong conclusions about the role that SPC played in what appears to be a reduction in goat numbers, and
2. It does not directly indicate whether removal of goats had any impact on threatened assets in the reserve area.

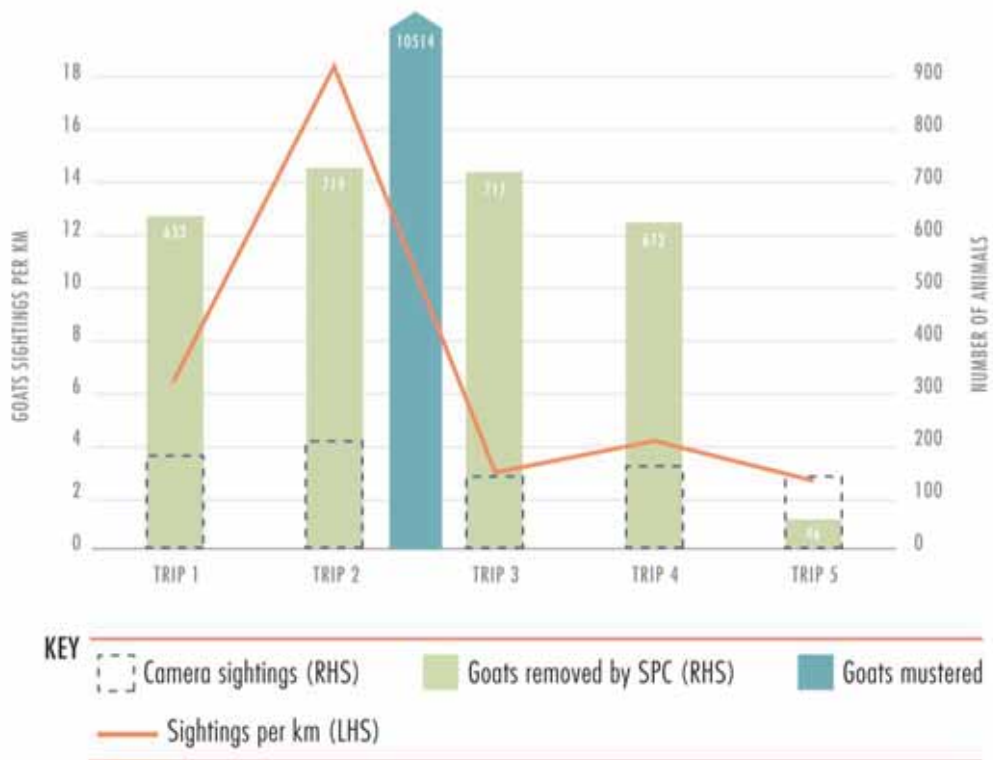


Figure 8: Central Mallee – Change in goat numbers

Yanga Complex– deer, pigs and rabbits

Over the course of the program six operations, which primarily targeted pigs and rabbits, were conducted at the Yanga complex with 981 pests removed over this time. Spotlight transects were used to monitor pest animals in the Yanga complex as part of the SPC trial. Some transects were not measured due to wet conditions. Monitoring results show that the trend in recorded deer and rabbit numbers, although reducing, is not significant with both species reducing by around ½ an animal per km (Figure 9), suggesting more-or-less stable populations over this time. Results for pigs show an initial doubling followed by a moderate overall decline by Trip 4 (<2 to <1 sighting/km).

However, the number of pigs and deer removed by SPC control measures rose significantly during trip 5, while numbers of rabbits removed fell over the five trips. The local population dynamics of these pest animals is clearly complex, with both pigs and deer numbers possibly responding to earlier SPC removals by new immigration into the area after trip 4's cull. On the other hand rabbit numbers did not rebound. It is likely that a combination of management (warren ripping for rabbits, baiting and aerial and ground shooting), climatic factors (rainfall, temperature) and ongoing impacts of the rabbit calicivirus also contributing to these changes.

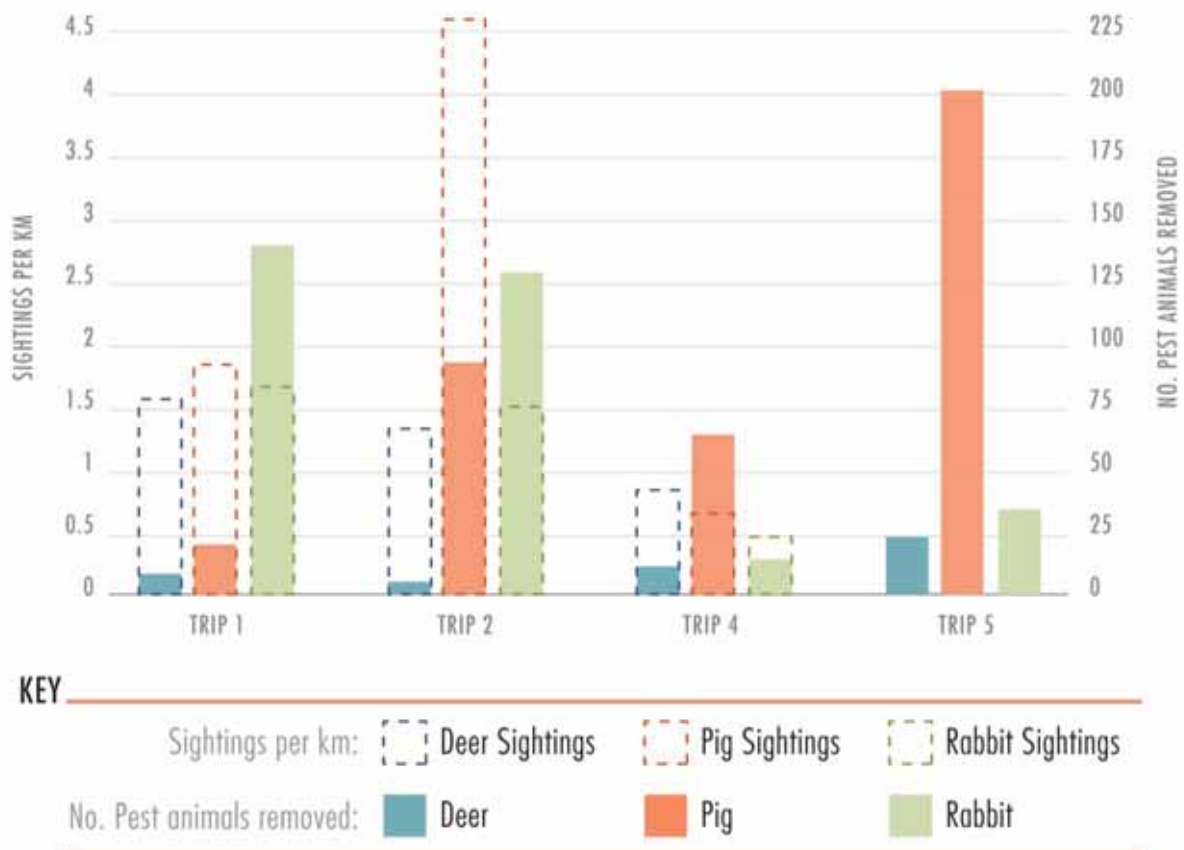


Figure 9: Yanga – Change in pest numbers

*Note: monitoring for sightings was not conducted during Trip 5

Cocopara complex – goats and pigs

Goats were monitored using faecal pellet transects in the Cocopara complex. 40 transects were located throughout Cocopara Nature Reserve providing an index of goat activity. The index shows that goat activity has declined over the past 2 years (2014 to 2016). However, due to the lack of information linking the index of goat activity to the actual goat population, the size of the decline is unknown. Results also show that the index is significantly affected by season with pellet count in spring higher than autumn (likely due to higher deposition rather than higher abundance). Due to a lack of comparison sites it is not possible to specifically point to a source of the goat decline. However, aerial shooting, SPC operations (which removed 88 goats), harvesting, as well as climatic factors, such as rainfall, are all likely to have influenced this decline.

Pigs were monitored on the same faecal pellet transects used for goats. Results show that pig activity has increased significantly in the past 2 years at a rate of approximately 50 percent a year, despite 18 pigs being removed by the SPC trial. The geographic extent of the pig population increase was explored further. The results showed there was no difference in the size of the population across the reserve, indicating the effects of the infestation have spread across the reserve.

Case study: Gundabooka National Park - goats

The goat population in Gundabooka National Park was monitored using two different techniques. On Mount Gunderbooka motion triggered cameras were used to measure goat activity in areas of conservation significance -near populations of curly-bark wattle and significant rock art sites. On the flat areas around Mount Gunderbooka faecal pellet transects were used to measure goat activity where the majority of management is undertaken (mustering, water point trapping, ground shooting).

Faecal pellet transects measured a significant decline in the goat activity over the monitoring period (approx. 68 percent decline per year). During this period there was an increase in the intensity of goat management including closure of water points, increased mustering and ground shooting. However, the macropod activity (simultaneous measure to goat activity) shows a similar trend (approx. 42 percent decline per year) suggesting that other factors such as climate have also influenced this decline.

There is little evidence to support a change in goat activity on Mount Gunderbooka between 2014 and 2016. However, goat activity in both spring and autumn 2015 was significantly higher than all other periods. Since there are no comparison sites it is uncertain whether this difference is a response to management or environmental conditions. Motion triggered cameras also suggest that goat activity was similar between the three camera sites. While goat activity was higher at the rock art site the difference was not statistically significant.

5.6 Social outcomes

The SPC trial has had positive social outcomes including improved communications with neighbours and volunteers, increased community awareness and support from Aboriginal and community groups. There remains minor concern from some neighbours regarding safety, animal welfare, cost effectiveness and negative perceptions of what the program entails. This requires continued engagement and management.

The Commission found that a significant success of the trial is the positive relationships developed between NPWS and SPC volunteers. This is evidenced by the responses in the field, post-operational surveys and various workshops.

5.6.1 Relationships with SPC volunteers

Between February 2014 and November 2016, volunteers contributed 331 days of their time to SPC trial operations (averaging 8.5 days per operation). Since the trial began, volunteers have consistently provided positive feedback regarding the quality of planning and execution, team work, safety, NPWS knowledge and expertise, communication and animal welfare. Post-operation volunteer surveys indicate that almost all volunteers felt their SPC experience was positive, with no negative comments registered.

Survey comments from volunteers included for instance:

"All NPWS staff (are) very knowledgeable, educational and kept firearms safety standards high. Animal welfare protocol always followed."

"Thank you to the NPWS staff involved for a safe and extremely well executed program."

"I feel privileged to be taking part and thankful for the opportunity."

"I have full confidence with the staff of SPC in all aspects."

"It was a positive experience where we have achieved our goals and I am proud to be part of it."

There is also anecdotal evidence to suggest that in addition to positive relationships, volunteers travelling to remote operations results in increased expenditure within regional communities, through accommodation and other travel related expenditures. During workshops volunteers highlighted this as an unforeseen and welcome additional economic and social benefit of the SPC trial.

5.6.2 Improved communication with neighbours

The Commission engaged Roberts Consulting Pty Ltd and First Person Consulting Pty Ltd to conduct surveys with SPC reserve neighbours, community and Aboriginal groups in July 2015 and October 2016. A total of over 160 surveys were conducted using different methods, including telephone interviews, online questionnaires and mail-out surveys with over 520 individuals contacted. A total of 82 neighbours responded to the July 2015 survey and 85 neighbours responded to the October 2016 survey representing an average response rate of 32 percent across the two surveys (Figure 10).

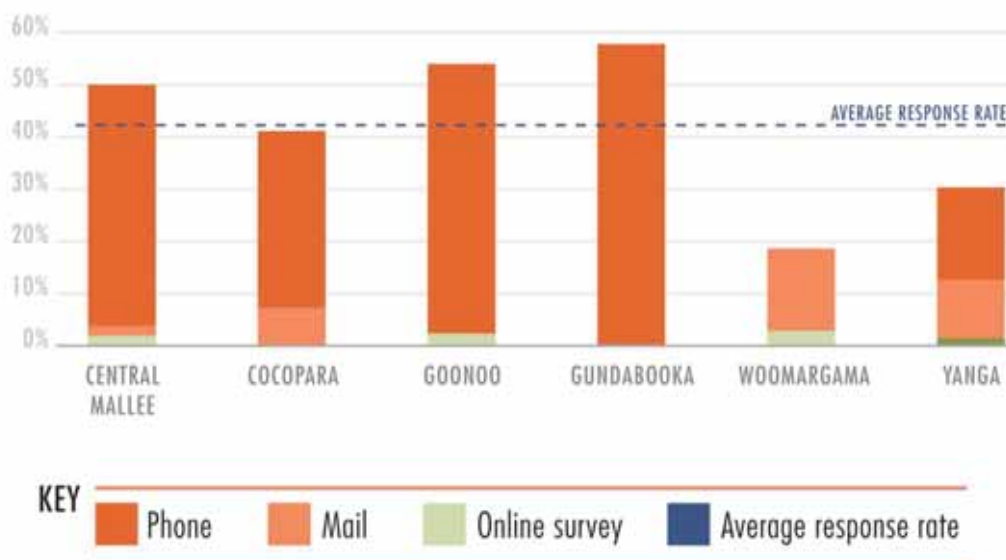


Figure 10: Combined response rates of neighbours to SPC 2015 and 2016 surveys

The Commission notes that the majority of survey respondents were satisfied (43 percent) or very satisfied (34 percent) with the information provided to them by the NPWS about the SPC trial (Figure 11). Only a small per cent (<13 per cent) of neighbours were dissatisfied with the information provided, with some indication that this level declined over time (Figure 11). However, overall satisfaction levels between the October 2016 and the July 2015 survey were not statistically significant (t-test, $p > 0.05$). The list of survey questions can be found at Attachment 5.

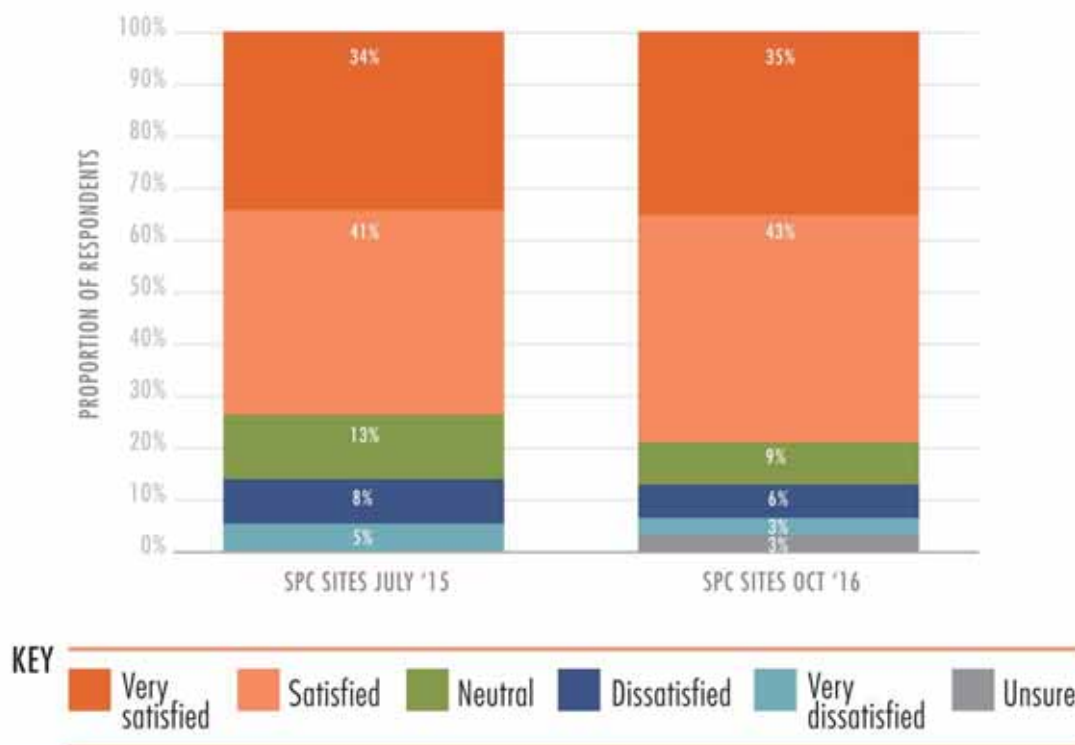


Figure 11: Neighbours level of satisfaction with the information provided to them by the NPWS about the SPC trial.

*Data presented for SPC sites surveyed in July 2015 (n=79) and October 2016 (n=63).

Example survey comments include:

The communication has been fantastic. (Goonoo survey respondent).

[They] always call me and give me plenty of notice. (Gundabooka survey respondent).

In terms of areas for improvement, seven respondents (8 percent) stated that they had either not heard of the SPC trial or had received no specific information about it. Furthermore, five requested more information about the outcomes and results of the SPC trial shooting operations conducted in their regions, one noting, for example:

The only information we've got is the information when something's going to happen. We haven't got any feedback about how it's working and what happened as a result. That would be interesting. But, overall they call us when a shoot is going to happen and that's the main thing. (Goonoo survey respondent).

However, in contrast to these requests for more information, some neighbours did appear to receive feedback about the outcomes of shooting operations:

[They're] very good at providing notice that a shoot is going to take place. That's all they need to do really. They're not obligated to provide us with details about the outcomes, but they do. They're fulfilling their role adequately I'd say. (Yanga survey respondent).

This indicates there may be room to improve consistency in post operation communications.

5.6.3 Aboriginal Groups

Interviews were conducted with six members of indigenous groups covering SPC sites at Cocopara, Central Mallee, Gundabooka and Yanga. No contacts were available for Goonoo or Woomargama sites.

Three of the six interviewees noted that they had not heard about the SPC trial. However, they also noted that their organisations' activities did not deal directly with the park/reserve in question. This suggests that NPWS may have contacted them to inform them of the SPC trial, but this information was overlooked or noted to be not relevant.

[We were] not aware of the trial. But they have been notifying us of what they've been doing about other stuff [related to pests]. (Central Mallee interviewee).

The remaining contacts noted that they had been informed about the program and its activities and had been satisfied, overall, with the level of communication.

[The communication has been] great. They inform us every time something's going on ... we're kept up to date with what's happening. (Gundabooka interviewee).

They advise us in writing, but we haven't been involved in the program itself. (Cocopara interviewee).

Of those that had been made aware of the SPC trial, one interviewee noted that more face-to-face communication would have been better, though another indicated that engagement with representatives of the Joint Management Committee she sat on was very good, and included site visits and direct engagement. This may reflect the extent of existing relationships between NPWS and some of the indigenous organisations with an interest in SPC sites.

Outside of the SPC trial itself, one interviewee suggested that there was a need for more follow-up communication after a pest control exercise, both in terms of what outcomes there were and whether any cultural heritage sites had been identified during the exercise.

All three of the interviewees who were aware of the SPC trial expressed support for its approach and intent. They noted the importance of pest management:

Pigs and kangaroos and rabbits – they are a concern for all the landholders out here. Damaging sites, damaging burial grounds. They're a problem for all land owners and people accessing the parks. (Cocopara interviewee).

They also expressed support for using volunteers, provided they were appropriately vetted and supervised:

[Pest control using volunteers] ... if they've got the licences, and the appropriate vehicles and that sort of stuff – but it needs to be controlled so that you don't have bush rangers going out there ... you need to make sure the guys that go out there aren't drop-kicks, that they have a good attitude and respect. (Yanga interviewee).

With respect to cultural heritage sites, all three respondents who were aware of the SPC trial were satisfied with how these sites had been managed as part of the trial.

We do have a site person, someone working on heritage, that works for parks as well, and keeps them up to date with all of that. I've got no problems or concerns there. (Gundabooka interviewee).

More broadly, one interviewee also expressed an interest in having more training around pests and pest management for local Aboriginal people:

More training with the group would be better – building their capacity. So in the future we could be involved in the actual shooting or removal. (Yanga interviewee).

5.6.4 User groups and other community members

Six respondents listed as community group representatives were interviewed as part of this final survey. However, two of these contacts were also listed as reserve neighbours and had already completed the landholder questions.

Four organisations were represented, three relevant to the Yanga and one to the Gundabooka SPC sites. Only two of the four respondents were aware of the SPC trial. One other respondent was aware of pig shooting operations undertaken in Yanga, but had not specifically heard of the SPC trial in their community group meetings. The fourth respondent (Gundabooka) had no knowledge or awareness of the SPC program or its relevance. We infer from the contact list that this was a Sydney school that uses or has used the Gundabooka site.

Both respondents who were aware of the program were satisfied with the level of information provided. Information was provided through letters, phone calls and direct engagement with NPWS staff.

We hear quite often about the SPC. I'm a member of the [advisory group] and our regional adviser gives us reports at our bimonthly meetings. (Yanga community group representative).

They certainly provided me personally with about five letters - as a neighbour, as a farmer and the fire captain. And then they give us a phone call too, and two rangers came to visit and discussed it with me. (Yanga community group representative).

Neither of the two respondents who were aware of the SPC trial had any concerns with the how the SPC operations were being carried out. However, one stated that they believed ground shooting to be an ineffective and inefficient method of pest control. The respondent noted they had raised their concern with the NPWS and were neither satisfied nor dissatisfied with NPWS's response. Neither of the two respondents aware of the trial reported any impacts on their groups or on pest species. They did note broader concerns related to its lack of efficacy and perceived political drivers.

For all the effort there's not a lot of result, but it's not because they didn't try. (Yanga community group representative).

It doesn't affect me in any way – apart from being a tax payer, and as a farmer, a neighbour and a concerned citizen. Government needed the support of the shooting party, but there are no pest control outcomes. (Yanga community group representative).

One interviewee noted, more generally, that the NPWS had been working well with the Local Land Services on various pest management programs in and around Yanga and that the SPC trial, in and of itself, had been well run.

From my understanding the Supplementary Pest Control trial has been extremely well run and National Parks, from my perception, have been happy with the people put forward to be part of it. (Yanga community group representative).

It is important to recognise that the feedback above was drawn from a very small group of respondents and may not be a good indication of NPWS's broader communication with relevant community groups. The low level of input from this stakeholder segment relates to the contact lists supplied by NPWS having few relevant and up to date stakeholders listed.

Overall, the low number of relevant groups is to be expected given the remote location and limited use of the parks in the SPC trial. Set against the good feedback from some of the stakeholder groups and the park neighbours, it appears that this may simply be a difficult area of engagement for NPWS. This area may need greater focus should SPC activities continue into the future.

5.6.5 Areas for improvement

The results of the surveys and interviews outlined above demonstrate a number of positive relationships have stemmed from the SPC trial to date. The data collected reveals that the majority of key stakeholder groups are pleased with how the program has been conducted and communicated.

The feedback received also indicates areas where communication could be further improved, including ensuring consistency of the level and quality of communication across SPC sites, further communication about the design and outcomes of SPC, and improved integration with pest management communication in general.

Specifically, the Commission recommends developing and using a stakeholder engagement strategy would significantly boost the positive messages stemming from the SPC trial. Evidence from surveys suggests that, without clear communication with neighbours about how the program is being run and what outcomes are being achieved, some misconceptions about the program are developing within some segments of the community. This is reflected for example in several comments expressing a perception that the program is inefficient because of the small number of animals removed, and in comments raising concerns over the qualifications of the volunteers.

In addition, improving communication with neighbours and key regional stakeholders about SPC operations has the potential to improve the management of pest animals across the landscape, and also on NPWS reserves.

5.7 Perceptions of pest control

Questions aimed at understanding the community's perceptions of pest control were included in the surveys undertaken. This data does not necessarily reflect actual variations in pest numbers, but is important for understanding community concerns in regards to pest management.

Almost all respondents considered the control of pests in NSW parks and reserves to be very to extremely important (up to 89 percent; **Figure 12**). These views do not explicitly endorse volunteer shooting of pests in parks and reserves, but were similar to those expressed by SPC trial site neighbours in July 2015. Neighbours of non-SPC sites (surveyed in April 2016) rated the importance of pest control slightly (but significantly) lower than respondents to the first survey of neighbours of SPC sites (**Figure 12**). This trend was also evident between the most recent survey and non-SPC neighbours, though the difference was not statistically significant.

In line with these attitudes on the importance of pest control, nearly all respondents supported pest control programs in NSW parks and reserves (**Figure 13**), with 84 percent reporting they strongly support them and 14 percent reporting they somewhat supported them. Only one respondent was "somewhat opposed" to such programs. There were no trends or statistical differences between neighbours' level of support reported in October 2016 as compared to SPC neighbours surveyed in July 2015, or in comparison to neighbours of non-SPC sites.



Figure 12: Survey respondents' perceptions of the importance of pest control activities in National Parks.

*Data presented for non-SPC sites surveyed in April 2016 (n=46) and SPC sites surveyed in July 2015 (n=77) and October 2016 (n=81). Letters indicate which groups are statistically similar to each other (i.e. those that share the same letter are not statistically different; t-test, p<0.05).

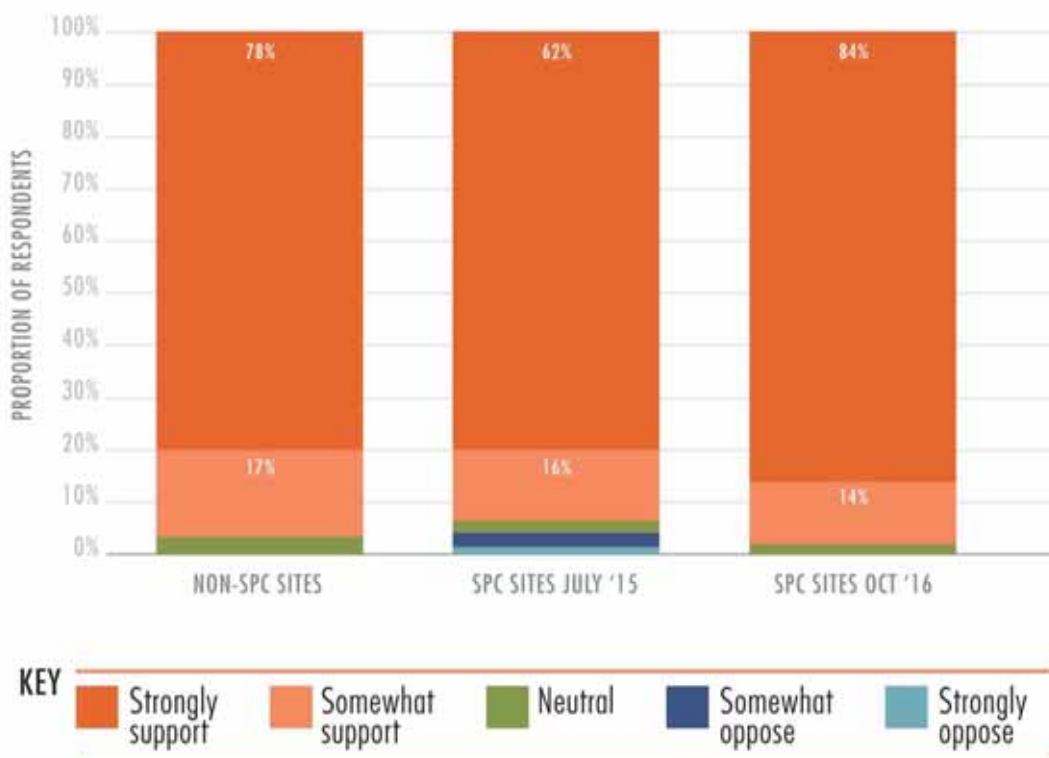


Figure 13: Neighbours support for pest control programs in National Parks.

*Data presented for non-SPC sites surveyed in April 2016 (n=46) and SPC sites surveyed in July 2015 (n=79) and October 2016 (n=81).

The majority of neighbours support ground-shooting as a pest control technique, with only 7 percent expressing opposition (**Figure 14**). Among the 12 unsolicited comments that this question prompted:

- five noted a view that ground-shooting is ineffective
- three noted that it should only be done by professionals
- two emphasised that it should be part of an integrated approach to pest control
- two called for higher levels of shooting.

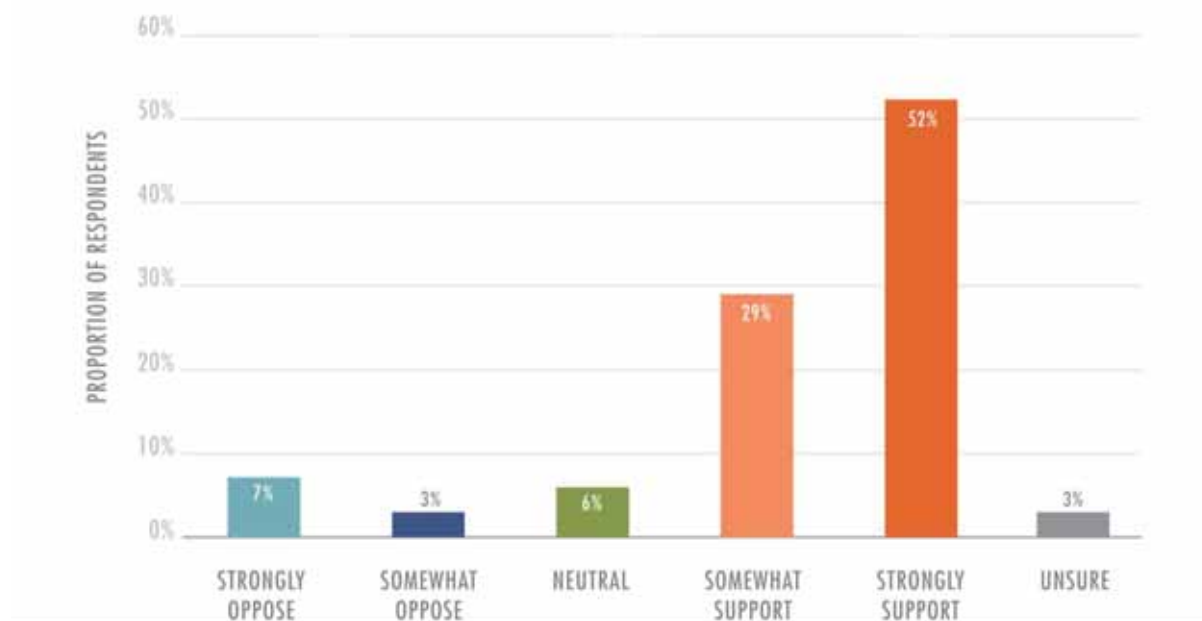


Figure 14: Survey respondents' support for using ground-shooting in National Parks as a pest management technique.

Some of the support expressed by neighbours for using volunteers for ground-shooting was qualified, including:

- 16 neighbours (19 percent) noted that they did not believe that the approach was effective (largely related to the low number of animals removed), including five who specifically noted that it was inefficient.
- Some noted that their support of the approach was contingent on volunteers being supervised, acting professionally and being appropriately qualified and skilled (17 comments).
- Some raised concerns about the qualifications (3 respondents), knowledge (4 respondents) and skills (4 respondents) of volunteers.
- Some felt that the use of volunteers and ground-shooting should only occur as part of a broader, integrated pest management strategy (3 respondents).
- Two respondents raised concerns about the politics surrounding the SPC trial.
- In contrast, two neighbours noted that the efficacy of the approach could be improved if controls and restrictions (e.g. daytime shooting) were relaxed. Two also noted that they were in full support, but not with respect to goats, which they derive an income from.

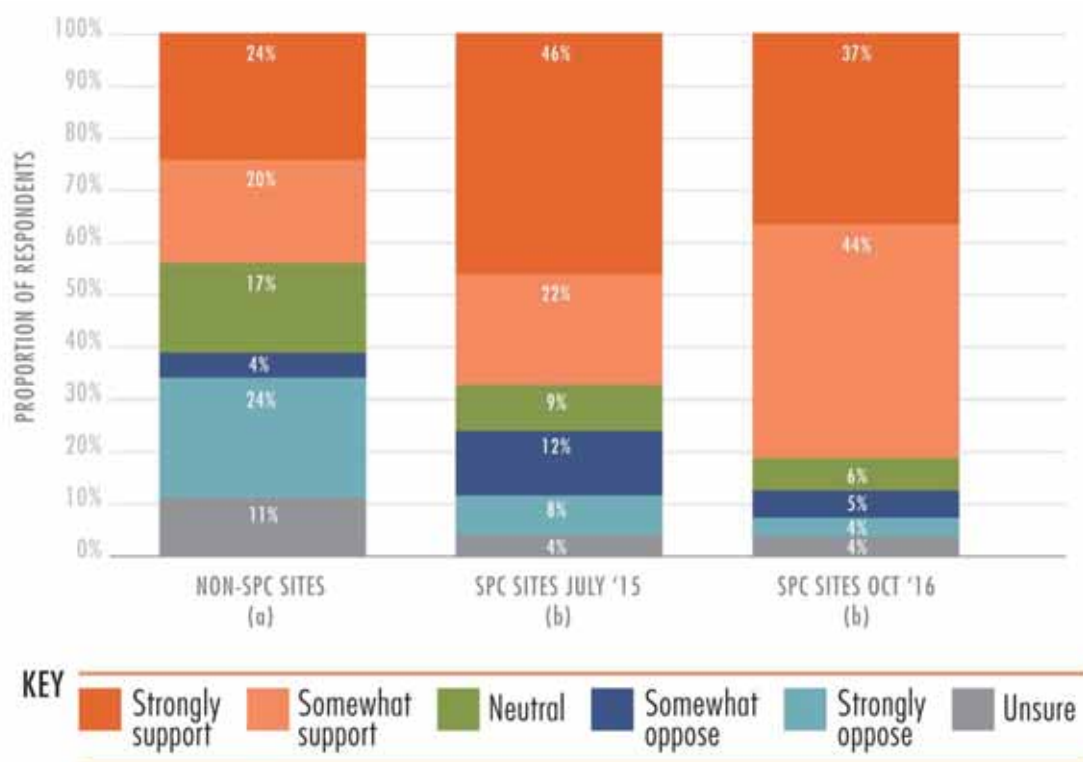


Figure 15: Neighbours support for using qualified volunteers to control pest animals through ground-shooting in National Parks.

* Data presented for non-SPC sites surveyed in April 2016 (n=46) and SPC sites surveyed in July 2015 (n=78) and October 2016 (n=81). Letters indicate which groups are statistically similar to each other (i.e. those that share the same letter are not statistically different; t-test, p<0.05).

Specific survey responses to the use of volunteer shooters were more mixed. Importantly, the support expressed by SPC park neighbours was significantly greater than the support reported by neighbours of non-SPC sites, where more than a quarter (28 percent) were somewhat or strongly opposed to using volunteers (Figure 15).

SPC neighbours also appeared to show more overall support in the most recent survey (October 2016; but these differences were not statistically significant from the July 2015 survey (81 percent vs 68 per cent) (Figure 15).

Perceived pest impacts

Park neighbours considered most of the species canvassed in the survey to have detrimental (or very detrimental) impacts on them (Table 11). In particular, feral pigs and foxes were most widely perceived as having detrimental impacts. More than half of respondents (57 percent; 43/76) noted feral pigs have a very detrimental impact.

Rabbits and wild dogs were also reported to be detrimental, though to a lesser extent. In each case, about two-thirds of respondents (64 percent and 67 percent, respectively) noted that they had detrimental or very detrimental impacts. Wild dogs, in particular, prompted strong responses and clear examples of impact:

Wild dogs - it's a touchy subject, they're too cunning. My neighbour lost about 70 sheep. (survey respondent)

Dogs are extremely detrimental. Wild dogs around here are very disconcerting - if I haven't got my gun with me it's a bit of a worry. I've seen what they do to cows and sheep and it's pretty crazy. (survey respondent)

Responses for feral deer and feral goats were more mixed. Feral deer were the least commonly cited species, with only 47 out of 85 (55 percent) respondents able to comment on their impacts. This is not surprising given the location of many of the reserves in regions where deer are not overabundant. Their impacts were also perceived to be far less detrimental, with one respondent noting that they were beneficial because of their aesthetic value.

Feral goats were perceived to be more detrimental than deer with 60 percent rating them detrimental. However, almost a quarter of respondents (22 percent) noted that they were beneficial or very beneficial. This relates to some landholders trapping or shooting goats for food or commercial purposes.

In addition to these key pest species, survey respondents also noted a range of other species that they regarded as pests with detrimental impacts (**Figure 16**). These species were not asked about directly, but were identified by participants. Four of these seven species were natives: kangaroos, emus, dingos and wombats. Most notably, almost a third of respondents (31 percent) considered kangaroos to have detrimental or very detrimental impacts.

Cats were another species of concern for 14 percent of respondents, with three respondents noting specifically that they need more attention.

Table 11: Perceived mean level of impact* from different pests at each SPC trial site according to park neighbours.

Key pest species	Mean level of impact					
	Central Mallee	Cocopara	Yanga	Goonoo	Gundabooka	Woomargama
Foxes	1.6	2.0	1.6	1.9	1.5	1.7
Wild deer	2.8	3.0	2.8	2.9		1.7
Wild goats	3.5	2.3	2.9	2.3	3.5	2.1
Feral pigs	1.7	1.3	1.1	2.0	1.5	1.4
Rabbits	2.5	2.7	1.6	2.3	2.0	1.8
Wild dogs	2.1	2.7	1.8	2.3	1.8	1.2

*Mean value calculated from scale of perceived impact ranging from “very beneficial” (5) through “no impact” (3), to “very detrimental” (1) – i.e. lower scores indicate more detrimental impact. Highlighted cells indicate the top pests from each site.

Most species that were not asked about directly, such as dingos, camels and carp, tended to be only mentioned by a few respondents in individual parks (**Figure 16**). Kangaroos and cats, in contrast, were mentioned by respondents across all parks (with the exception of cats at Cocopara). Around half of respondents in Yanga and Goonoo mentioned kangaroos (46 percent and percent, respectively).

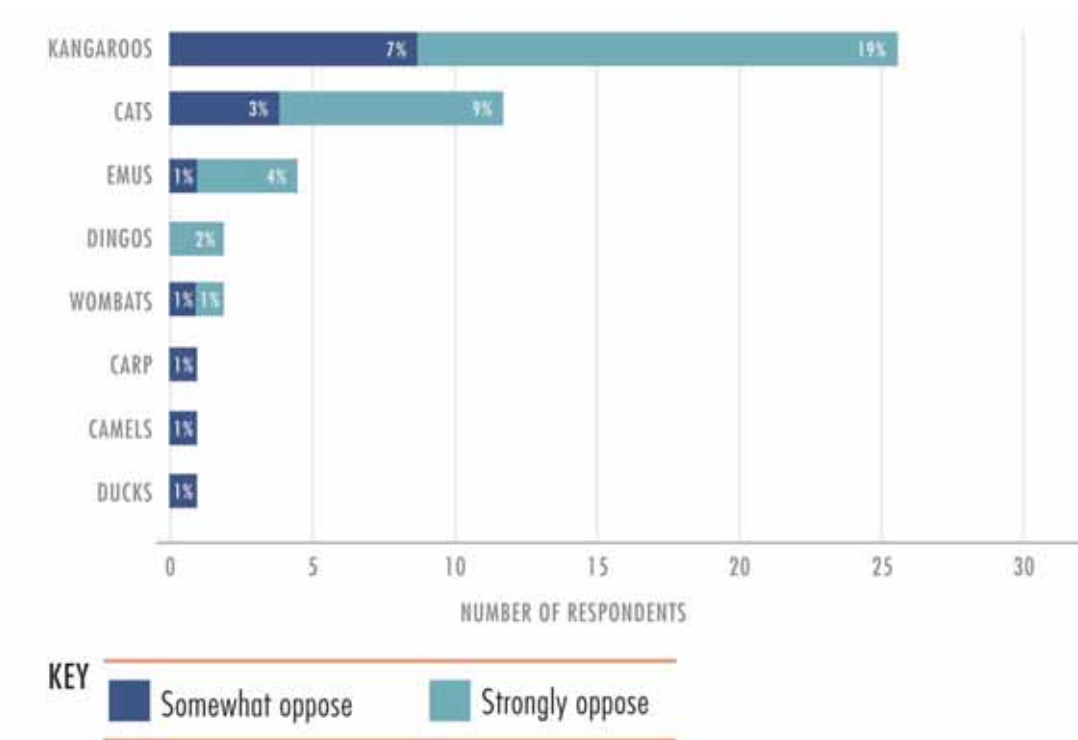


Figure 16: Other species identified by survey respondents as having a detrimental impact

Perceived changes through time

Park neighbours’ perceptions of changes to the impacts of pest species are difficult to draw clear conclusions from and should be interpreted cautiously. The majority of respondents reported that the impacts from pest species were “about the same” as they were in January 2014. On average, around two-thirds of respondents (64 percent) reported no change in impacts. The exception was feral pigs, where impacts appear to have changed more notably (for better and worse) with only 38 percent of respondents reporting no change.

Survey respondents that did observe changes reported a mix of both worsening and improving impacts from key pest species. First Person Consulting converted neighbours’ responses to a mean score for each park (ranging from -2 (much worse) to 2 (much better) to compare the final survey to the first SPC survey (July 2015) and a survey of non-SPC sites. That comparison of perceptions of change suggests that:

- Foxes, goats and rabbits show a slight trend in improvement (a lessening of impacts) at SPC trial sites since January 2014 (when surveyed in October 2016). Improvements, however, are small and rabbits were the only species to have improved significantly (i.e. the improvement is significantly different from “no change” (0)).⁹
- Feral deer and pigs appear to have been more stable, while there is a slight, but non-significant worsening in the impacts of wild dogs.
- These are set against a slight (but not significant) trend that suggests a worsening of impacts from foxes, feral goats and feral pigs at non-SPC sites (when surveyed in April 2016).

5.8 The cost of the trial

For this review the NPWS SPC team provided the Commission with operational, volunteer and NPWS staffing data. Data was also provided for total SPC trial costs. These costs were broken

⁹ One-sample t-test, n=6, p<0.05.

down into sub-categories based on NPWS estimates. The average costs outlined in **Table 12** should be treated cautiously, as estimates only.

The Commission notes that the SPC trial has demonstrated ongoing improvements in efficiency and its continuation would effectively leverage already sunk costs. Costs per planned operation have declined by around 89 percent since trial commencement and 59 percent since July 2014.

Table 12: SPC trial average costs

Year	Ave. cost per planned operation	Ave. cost per planned volunteer day	Planned operations	Completed operations	Cancellations	Volunteer days	NPWS SPC staff days
2013/14	\$253,167	\$37,975	3	3	nil	20	104
2014/15	\$66,223	\$6,971	18	16	2	143	350
2015/16	\$49,973	\$4,759	22	16	6	158	226
2016/17	\$27,222	\$3,691	16	5	11	36	77
Total			59	40	19	363	757

* Note the cost per volunteer day excludes monitoring costs.

Analysis of trial costs included a review of year-on-year financial cost data, staffing and volunteer hours, and interviews with the NPWS SPC coordinator and senior management.

The total cost of the SPC trial was \$5.9 million, which represents an underspend of \$5.1 million from the original \$11 million allocated for the trial. The majority, 65 percent, of expenditure was spent on SPC staff costs, which included operational planning, ecological monitoring, and the conduct of operations. The balance of expenditure was almost evenly split between program design, volunteer administration, equipment, evaluation with a small amount spent on illegal hunting compliance (a function which was transferred to another area of NPWS toward the end of the trial (See **Figure 4** in Section 4.5)).

Program operational costs can be broken down into a number of sub-components (see **Figure 17**). These costs are almost equally split between monitoring, shooting operations and coordination with the balance of the program costs allocated to administration and equipment.

Leveraging of sunk costs and progress to date

Almost 20 percent, or \$1.1 million, of the trial was associated with sunk costs such as equipment, (\$0.37 million) and program design and establishment (\$0.64 million). These costs have not fully been leveraged to date and should the trial continue there is scope to leverage these sunk costs further.

In addition to actual costs incurred, there has been significant progress made in building relationships and adapting the program design, which can be leveraged if the program continues. In particular, NPWS have developed significant goodwill with SSAA NSW, volunteers, park neighbours, community and Aboriginal groups (see Social Outcomes, Section 5.6). The Commission has not sought to value this goodwill. However, it should be recognised and is in stark contrast to some negative attitudes toward the trial when it commenced. This goodwill provides a platform to foster additional successes in community engagement across NPWS. Further, many of the staff participating in the program noted the effort already put into establishing how to improve coordination between centralised SPC staff and regional staff.

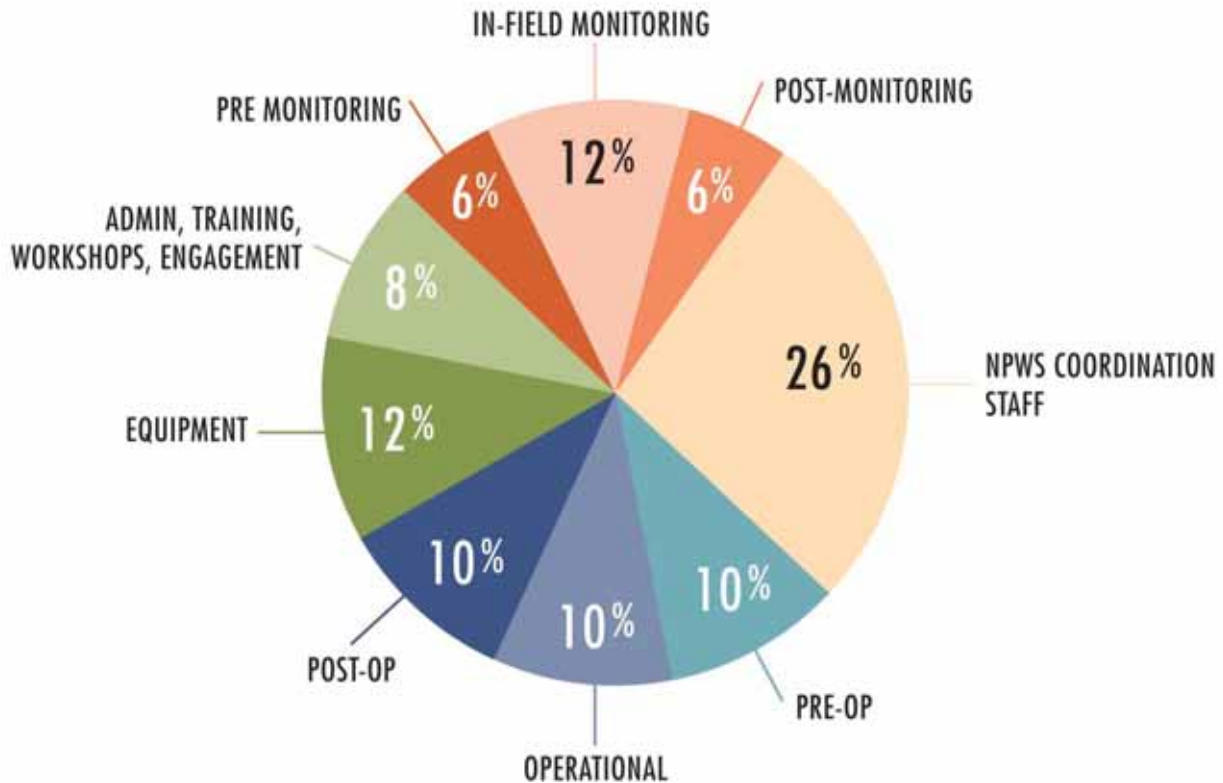


Figure 17: Breakdown of operational costs

Cost reductions and efficiencies

The Commission is of the view that ecological monitoring, although critical to the ongoing monitoring of pests impacts and pest management outcomes, is not unique to SPC and therefore can be incorporated into the broader NPWS budget. Therefore, moving forward it is recommended that SPC monitoring should be integrated with other park ecological monitoring programs. The Commission notes that this has already occurred for a number of SPC monitoring sites that have been incorporated into Saving Our Species projects. Removing these program costs from the SPC budget could reduce costs by 23 percent.

Significant cost efficiencies have been observed over the trial period. Average costs per planned operation (excluding monitoring costs) declined 74 percent between 2013/14 and 2014/15 and a further 59 percent between 2014/15 and 2016/17 (Figure 18). In the final year of the trial the average cost per planned volunteer day (excluding monitoring) was \$3,691 which was down from \$6,971 in 2014/15 (Table 12). When monitoring is included, cost declined by 82 percent between 2013/14 and 2014/15 and a further 47 percent between 2014/15 and 2016/17. Average costs per planned volunteer day was \$4,820 in the final year of the program down from \$9,102 in 2014/15.

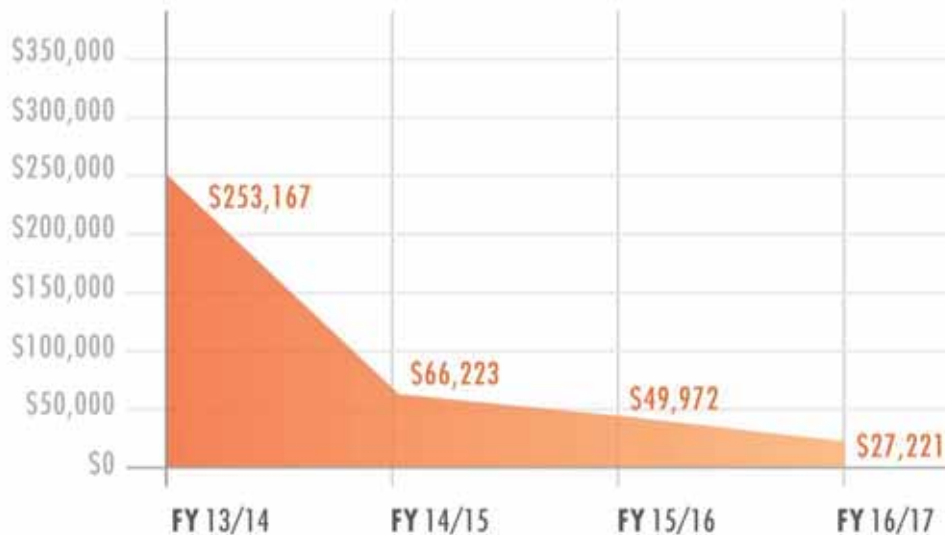


Figure 18: Decline in average cost per planned operation (ex. monitoring)

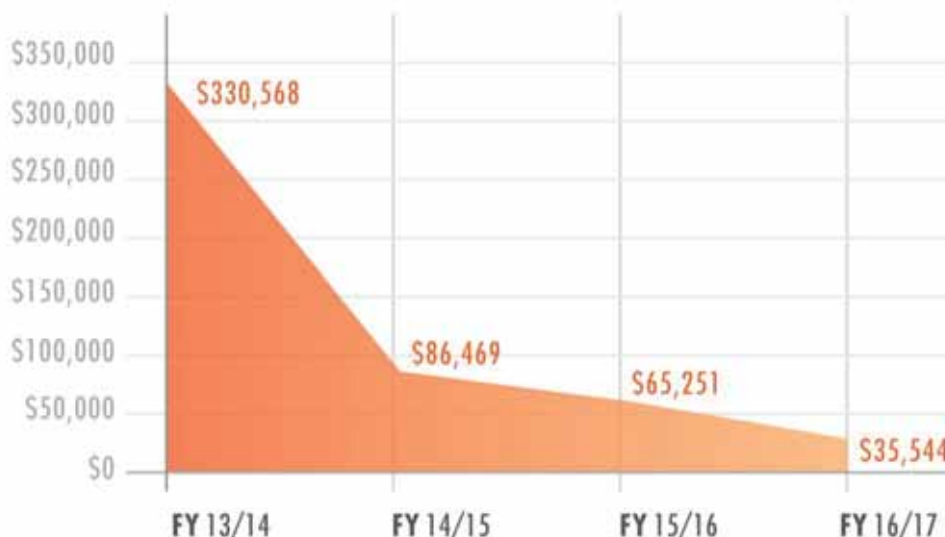


Figure 19: Decline in average cost per planned operation (incl. monitoring)

Total average costs per completed operation also declined over the trial. Average costs per completed operation declined from over \$17,000 in the first half of 2014 to around \$12,000 by the end of the trial (Figure 20). Figure 20 shows that these savings were achieved by eliminating overtime and significantly reducing costs of meals, accommodation and incidental expenses. Total average monitoring costs also declined significantly over this period for similar reasons (Figure 21).

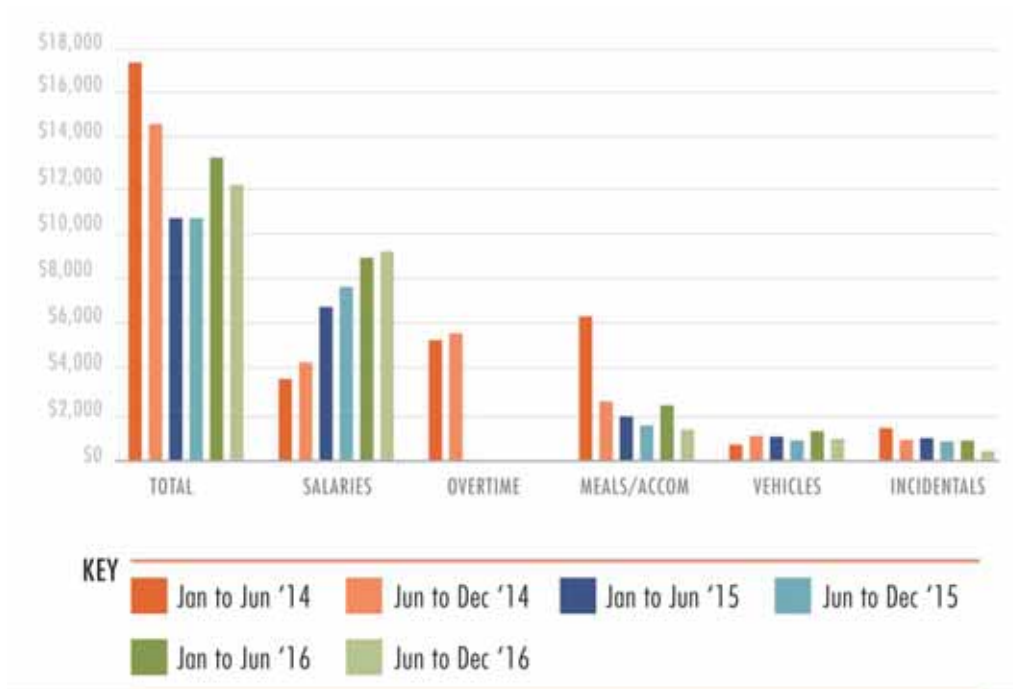


Figure 20: Average costs per operation (incl. pre and post operation costs)

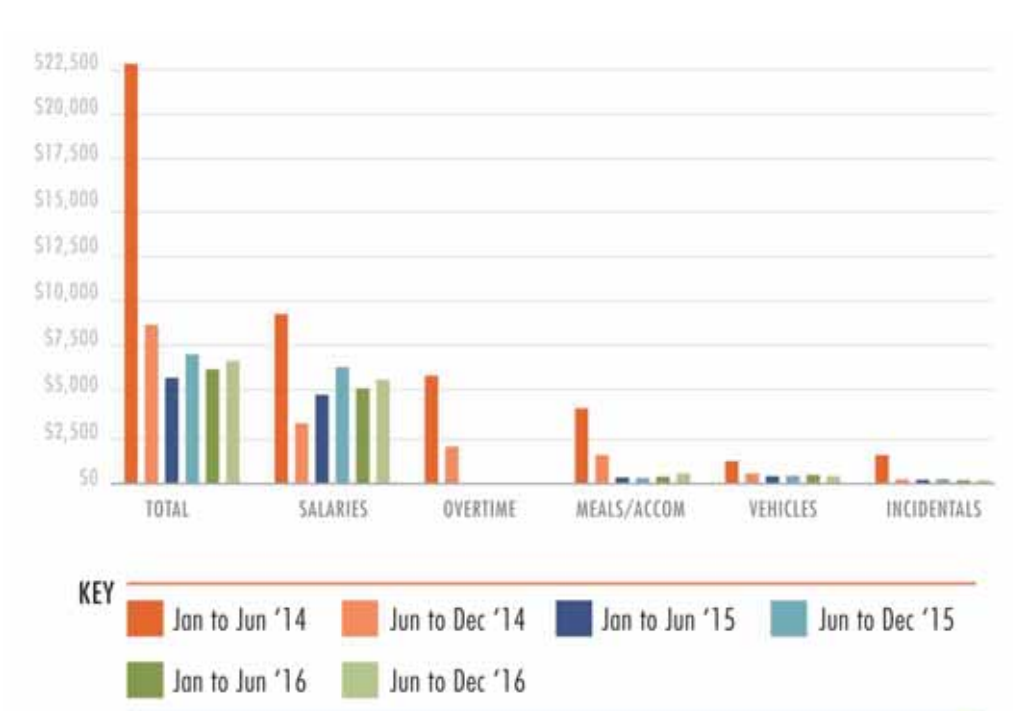


Figure 21: Average monitoring costs

*note: all years excluding 2016 exclude pre and post monitoring costs

Cost reductions for the trial have been found through improved planning, which has reduced the need for overtime, changes in staffing ratios, reduced use of access control staff at some complexes during operations, and improved meal and accommodation arrangements.

Field observations and interviews with NPWS SPC staff indicated that further efficiencies could be found if the program were to continue by undertaking more operations and through more improvements in coordination and operational planning. As noted above, costs associated with

equipment and some aspects of administration are likely to be lower, should the program continue, as much of these costs were associated with the trial start-up.

As noted by the Commission in its 2014 evaluation of the SPC program design, the selection of SPC reserves may have had an impact on the effectiveness and efficiency of the trial. A subsequent review of literature, interviews and research highlighted in the Commission's 2016 report *Shared problem, Share Solutions, State-wide review of pest animal management*, indicates that the coordinated integration of pest management activities across tenures ensures the most effective and efficient pest management outcomes.

The restriction of the trial to only 12 reserves has inevitably limited the ability of the trial to deliver meaningful and lasting pest management outcomes. This is not a surprise as complex trials of this nature are primarily focused on designing and road-testing the broad arrangements and methods for effectively and safely delivering the programs longer-term outcomes.

This review confirms that under NPWS management, the SPC trial successfully designed and implemented a safe volunteer-shooter based pest animal control program over three years. Over this time the trial fostered new professional partnerships between the NPWS, the broader community, local landowners and recreational hunters and shooters while further reducing the numbers of priority pest animals in the trial regions.

Attachments

Attachment 1: Terms of Reference

TERMS OF REFERENCE FOR THE EVALUATION OF THE SUPPLEMENTARY PEST CONTROL TRIAL PROGRAM

Background

The NSW Government has decided to:

- implement a program of Supplementary Pest Control (SPC) in national parks and other reserves using volunteer shooters who will be regulated, scheduled and carefully managed by the National Parks and Wildlife Service (NPWS); the purpose of this program is to assist in controlling pest animals by complementing ongoing NPWS pest control programs;
- commence the program, initially as a trial, in 12 reserves;
- independently evaluate the trial before any further rollout of the program.

These Terms of Reference outline how this evaluation will be conducted.

Evaluation of the SPC trial

The Premier and the Minister for the Environment requests that the Natural Resources Commission (the Commission) evaluate the SPC trial program to assist the NSW Government in deciding whether, and how, to proceed with the proposed SPC trial (beyond the trial period).

The Commission will independently evaluate the effectiveness and efficiency of the SPC trial program based on robust, evidence-based exploration of key issues. In developing its advice the Commission should consider issues such as (but not limited to):

1. the effectiveness of the SPC trial program in contributing to the aims and objectives of existing NPWS pest control programs, including
 - a) evidence that relevant native species populations have been additionally protected by the SPC trial
 - b) evidence that impacts of pest animals on neighbouring landholders and on the environment have been reduced
 - c) evidence that the number of pest animals taken by volunteers contributes to the existing NPWS pest animal programs (giving consideration to relative timing of control activities)
 - d) evidence that good animal welfare standards have been maintained
 - e) evidence that the SPC trial has been successfully aligned with and integrated into existing NPWS pest control programs, including evidence of any impacts on NPWS park operations
 - f) evidence that the SPC trial has been conducted in a manner consistent with the program approved by Government, that appropriately manages risk, that complies with relevant legislation and aligns with Government priorities (such as the NSW Biosecurity Strategy and NSW2021).

2. the efficiency of the SPC trial program, including
 - a) the costs and benefits of the trial to the NSW Government and to regional communities
 - b) how the SPC trial program compares to alternative uses of the available resources that may achieve similar outcomes
3. the social impacts of the SPC trial.

Any recommendations from the Commission should include potential improvements to the SPC trial to enhance effectiveness and efficiency, if the program is to continue after the trial.

The Commission should also have regard to the following in undertaking the evaluation:

- any broader research carried out by the Department of Primary Industries on hunting as a pest control technique
- best practice in pest control programs and their evaluation in other jurisdictions.

The Commission should consult with relevant stakeholders in conducting their evaluation and in developing recommendations, including park neighbours, Aboriginal communities, Local Land Services, NPWS staff, volunteers and shooting organisations involved in the trial, other members of the hunting community, conservation and animal welfare groups, recreational users of parks and reserves, and tourism providers.

The Commission should also consult technical experts with pest management expertise and ecological, economic and social science skills including the Office of Environment and Heritage (OEH), Department of Primary Industries and universities conducting relevant research.

The Commission should work closely with the Office of Environment and Heritage (OEH) in designing and conducting the evaluation.

Evaluation outcomes and recommendations rely heavily on the design of the trial, the availability of existing data (including baselines) and information on existing NPWS pest control programs, as well as any additional data that can be collected during the three year trial. OEH will be responsible for the collection and quality of data from existing NPWS pest control programs and from the SPC trial, as required by the evaluation.

For some elements of the evaluation, conclusive, scientifically reliable evidence at all sites may not be achievable within the timeframe of the trial (three years). In this instance the best available alternative sources of evidence will be sought.

The Commission is to provide:

- interim evaluation reports, including draft findings
- a final evaluation report, including outcomes of the evaluation and recommendations to Government, by 31 May 2017.

Amendments

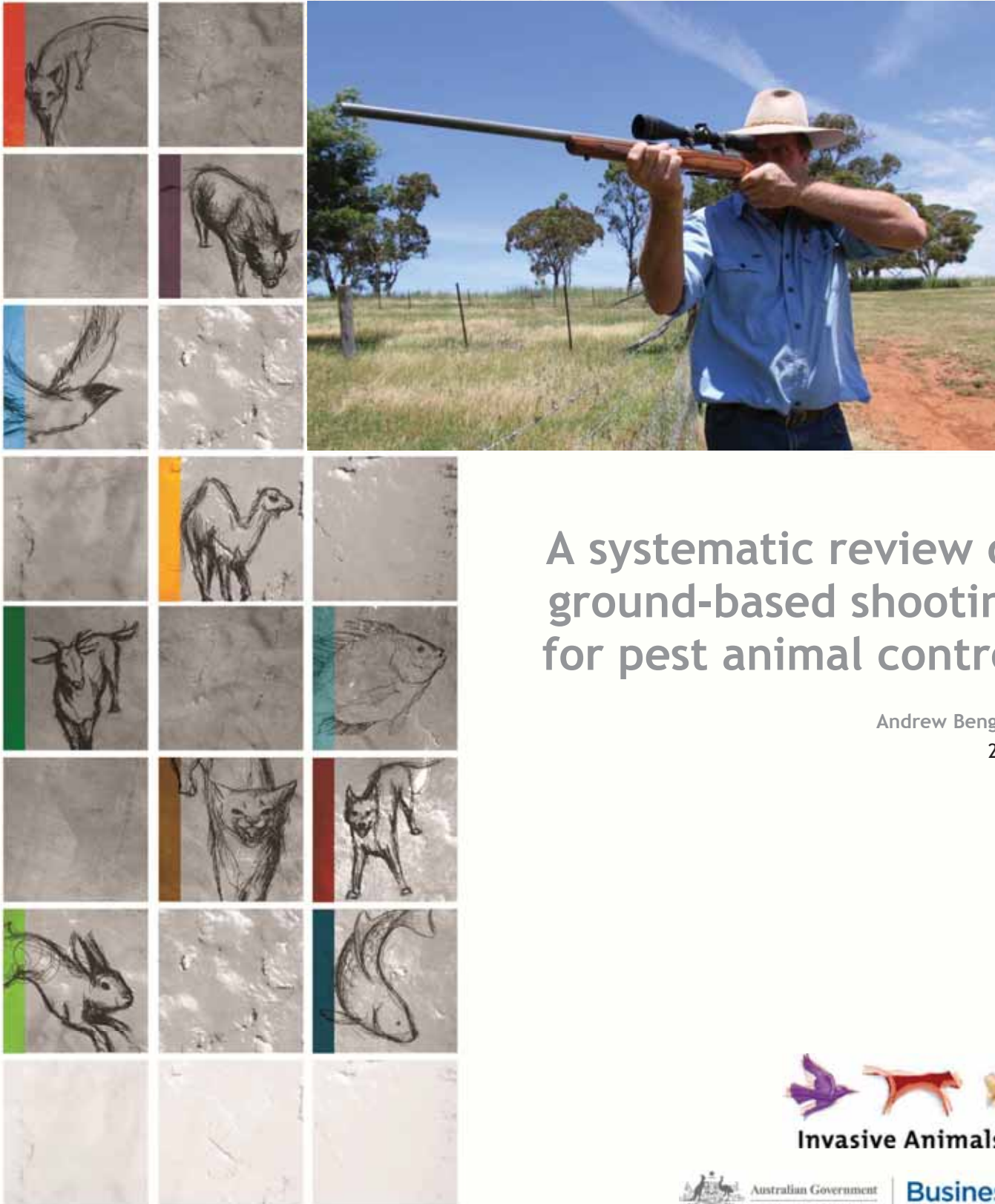
Any changes to these Terms of Reference may be made by the Minister for Environment and the Premier and will be published on the website of the Office of Environment and Heritage and the Natural Resources Commission.

Attachment 2: Evaluation framework and logic

Evaluation framework questions	Questions on trial design addressed in this report	Interim report	Final report
K1: Should SPC proceed beyond the trial period, and if so, how?			
KS1: To what extent could SPC improve outcomes and/or reduce the cost of existing NPWS pest programs?			✓
KS2: Under what circumstances is SPC (as a technique) most useful?			✓
KS3: What improvements could be made so that SPC works better and costs less in the future?		✓	✓
K2: How effective was the SPC trial?			
KS4: To what extent has the SPC trial contributed to existing NPWS pest programs (including alignment and integration)?	K2(iii): Is it designed to be aligned with existing pest management programs? K2(iv): Are governance arrangements, roles and responsibilities appropriate?	✓	✓
KS5: To what extent have negative impacts of pest animals on neighbours been reduced?			✓
KS6: To what extent have relevant native species populations been additionally protected?	K2(ii): Is it designed to be aligned with government priorities, particularly pest management and threatened species priorities?	✓	✓
KS7: To what extent was the SPC trial implemented in compliance with relevant legislation and Government priorities?	K2(i): Is it designed to be compliant with legislation? K2(ii): Is it designed to be aligned with government priorities, particularly pest management and threatened species priorities? K2(iv): Are governance arrangements, roles and responsibilities appropriate?		✓
KS8: To what extent were human safety risks appropriately managed?	K2(i): Is it designed to be compliant with legislation? Are SPC staff and volunteers appropriately qualified and trained? K2(vi): Are appropriate risk management plans and processes in place for human safety and animal welfare risks?		✓
KS9: To what extent were animal welfare risks appropriately managed?	K2(i): Is the trial designed to be compliant with legislation? K2(v): Are SPC staff and volunteers appropriately qualified and trained? K2(vi): Are appropriate risk management plans and processes in place for human safety and animal welfare risks?		✓
	K2(vii): Is the ecological monitoring framework designed to report on trial outputs and inform the evaluation?		
K3: How efficient was the SPC trial?			
KS10: What were the costs and benefits of the SPC trial to Government?		✓	✓
KS12: Has the efficiency of the SPC trial improved over the period of the trial?		✓	✓
K4: What were the social impacts (intended or unintended) of the SPC trial?			
KS13: What were the impacts on volunteers and associated organisations?		✓	✓
KS14: What were the impacts on park neighbours and Aboriginal communities involved in joint management?	K4(i): Are park neighbours being effectively engaged in order to identify any unintended (positive or negative) impacts?	✓	✓

Evaluation framework questions	Questions on trial design addressed in this report	Interim report	Final report
KS15: What were the impacts on regional communities including park users, local Aboriginal communities etc.?		✓	✓

Attachment 3: A systematic review of ground-based shooting for pest animal control, Invasive Animals Cooperative Research Centre.



A systematic review of ground-based shooting for pest animal control

Andrew Bengsen
2016



Invasive Animals CRC



Business
Cooperative Research
Centres Programme



A systematic review of ground-based shooting for pest animal control

Andrew Bengsen

NSW Department of Primary Industries

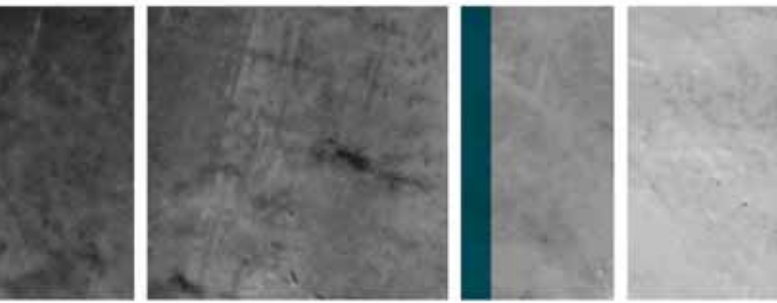
Vertebrate Pest Research Unit

1447 Forest Rd
Orange NSW 2016

2016

An Invasive Animals CRC Project





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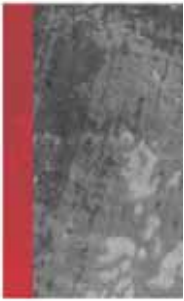
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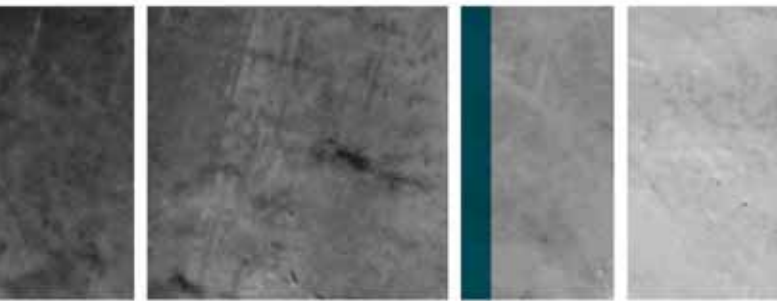
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Front cover photo: Peter West



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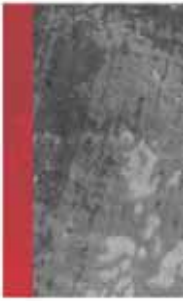


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Executive Summary

Ground-based shooting is commonly used to try and reduce the impacts or abundance of over-abundant animal populations in many parts of the world. It encompasses a wide range of activities carried out by many different types of people driven by a variety of interacting motivations. Given this contextual complexity, it is unsurprising that results of ground shooting operations for pest animal control range from counter-productive to highly effective.

This review systematically examines a sample of published papers that report on the efficacy of ground-based shooting operations in Australasia, North America, Europe and Japan. Although the sample was small and the literature surveyed included many flaws and inconsistencies, several key themes that contribute to effectiveness were identified. These included: 1) the use of tools or methods that enhance efficiency; 2) a manageable geographic area of operations; and 3) the use of highly skilled and committed shooters. Factors repeatedly shown to detract from efficacy included: 1) the inability of harvest-oriented shooters to sustain effort as target populations declined; 2) insufficient spatial or temporal coverage to counter immigration; and 3) the presence of refugia within treatment areas.

It is clear that ground shooting can make important contributions to the management of pest or over-abundant species, but shooting alone is often insufficient or prohibitively inefficient to achieve desired outcomes. Managers planning to use ground shooting as part of a population management strategy should: 1) carefully examine the options to determine what type of shooting operation is likely to be most useful; 2) establish and monitor meaningful objectives; 3) ensure that operations are sufficiently resourced to meet and maintain those objectives; and 4) integrate ground shooting with other control methods wherever possible. Operations that are poorly-planned, resourced, integrated and executed are unlikely to deliver useful outcomes. Ground-based shooting is rarely, if ever, a cheap and easy method for reducing pest impacts or abundance.

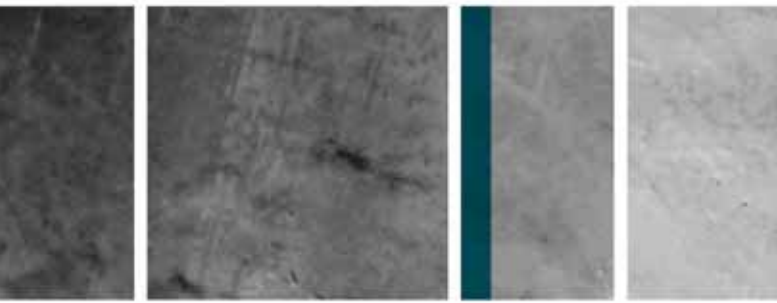
Review Panel

An initial draft of this report was reviewed by an external expert panel comprising:

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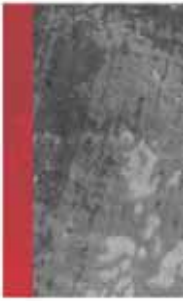
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Abbreviations

AO	Area of operations
DPI	NSW Department of Primary Industries
OEH	NSW Office of Environment and Heritage
SSAA	Sporting Shooters Association of Australia inc.
TI	Thermal imaging



1. Introduction

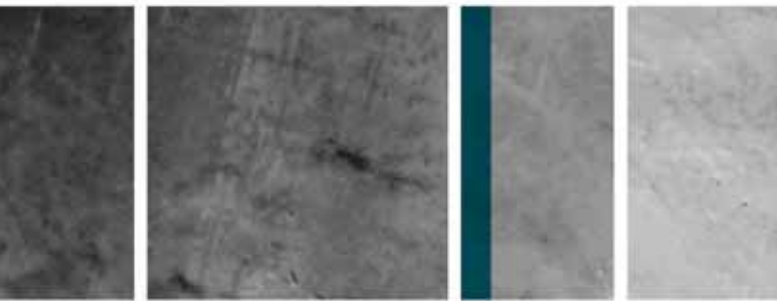
Natural resource managers and landholders in many parts of the world use ground-based shooting programs to reduce the density of pest or over-abundant animal populations in order to protect environmental, agricultural or other valued assets. These programs span a spectrum of management intensity ranging from highly organised shooting operations using professional teams to achieve specific measurable objectives (e.g. Barron et al. 2011) to laissez faire programs in which recreational hunters are allowed to harvest over-abundant species at their leisure (e.g. Massei et al. 2015). In Australia, shooting has been a popular method for controlling a wide range of pest animals (Reddiex et al. 2006, West & Saunders 2007).

Despite the importance that resource managers often place in ground-shooting, in Australia and internationally, its efficacy as a control tool has rarely been tested (Rutberg 1997, Reddiex & Forsyth 2006, Bengsen & Sparkes 2016, Davis et al. 2016). Furthermore, there may be a publication bias towards favourable evaluations (Peterson & Nelson 2016). It is, therefore, often difficult for managers to accurately predict the likely value of ground-based shooting as a pest control tool for any given situation, and therefore to determine how it might best be integrated into, or left out of, strategic pest management programs. In many cases, the choice to use shooting as a control tool seems to be based on practical or political convenience, or simply because there seems to be no other option available except doing nothing (Rutberg 1997, West & Saunders 2007). Nonetheless, the use of ground-based shooting as a pest control tool appears to be increasing in many parts of Australia. This apparent increase coincides with an upsurge of organisation and lobbying by groups representing recreational hunters, and also with the availability of new tools that have the potential to increase the efficiency of professional shooters.

This report describes the outcomes of a systematic review of published literature that aimed to evaluate the potential value of ground-based shooting as a vertebrate pest control tool, particularly in the contemporary Australian context. First, the scene is set with a brief survey of the broad range of shooting types conducted in Australia and internationally. This is followed by an examination of select local and international case studies that describe the effectiveness of ground shooting programs in different situations. From this examination, several generalisations are drawn about when, where and how ground shooting is most likely to be effective. In particular the review aims to determine whether the effectiveness of ground shooting for pest control operations tend to vary according to:

1. The status of the shooters involved (government, professional or unpaid);
2. The primary motivation for organising the shooting activity;
3. The geographic scale of operations;
4. Whether shooting is integrated into a management strategy that also uses other control methods.

The conclusion includes a short series of recommendations for resource managers considering the use of ground shooting as a pest animal control tool.



1.1 Ground shooting for pest control in Australia

There are many different ways in which ground shooting can contribute to pest management objectives. These can be classified using a typology based on the type of shooters involved, the primary motivation for the operation and the tenure of the land on which the operation is conducted (Figure 1). Some pest management programs may combine different types of shooting operations as part of a broader strategy. Also, nil tenure pest management, in which management tactics are planned without reference to property boundaries (Fleming et al. 2014), can result in some overlap at the lowest level of organisation. Nonetheless, the basic typology provides a useful construct for evaluating the effectiveness of shooting operations as a pest control tool.

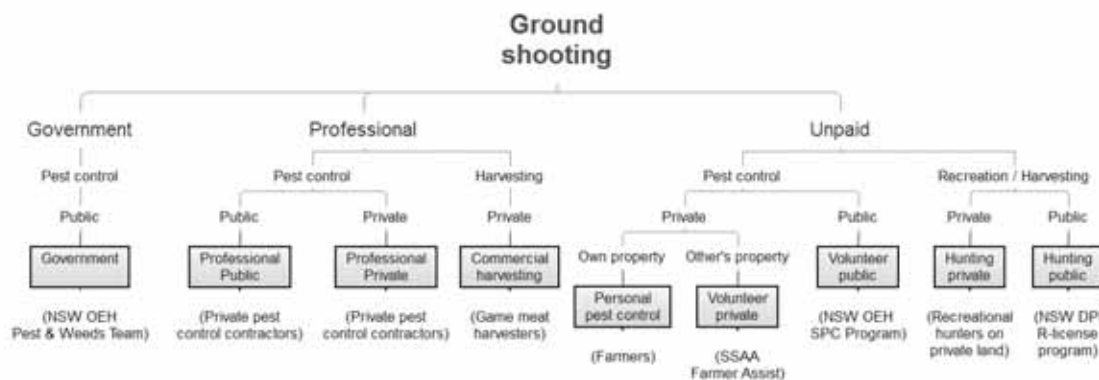


Figure 1: A hierarchical typology of different classes of ground shooting operations organised by the employment status of the shooter, the motivation for organizing the operation and the tenure of land on which operations are conducted. Examples of each type are shown in the lowest level.

Currently, ground shooting is used in programs aiming to control wild dogs (*Canis spp.*), foxes (*Vulpes vulpes*), cats (*Felis catus*), rabbits (*Oryctolagus cuniculus*), pigs (*Sus scrofa*), goats (*Capra hircus*), deer (*Cervidae*), macropods and native waterfowl (Grigg, 1995, Bomford & Sinclair 2002, Reddiex et al. 2006, West & Saunders 2007). It is not possible to estimate the relative importance of different types of shooting operations to the control of each of these species. However, ground shooting has traditionally been regarded as an important tool for managing deer and cats because few other options have been available for these species (West & Saunders 2007, Davis et al. 2016).

While recreational hunting is, by definition, not primarily intended to achieve pest control objectives, a recent survey estimated that between 200,000 and 350,000 hunters used public or private land to hunt introduced species in Australia (Finch et al. 2014). Contrary to North America and Europe (Enck et al. 2000, Massei et al. 2015), the numbers of hunters in Australia appears to have increased in recent decades (Franklin 1996, Bengsen et al. 2016), although numbers remain small when standardised by area (Table 1). There is much uncertainty around the role of recreational hunting as a pest control tool in Australia (Bengsen & Sparkes 2016).

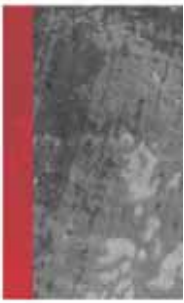


Table 1: Estimated numbers of active recreational hunters in 13 countries, ordered by decreasing number of hunters per square kilometre.

Country	Year	Number of hunters ($\times 10^6$)	Per cent of total population	Hunters km^{-2}
Spain	2011 ³	1.07 [†]	2.28	2.12
Italy	2012 ³	0.62 [†]	1.03	2.05
France	2012 ³	1.16 [†]	1.76	1.80
Portugal	2011 ³	0.14 [†]	1.35	1.53
United States	2011 ⁵	13.70	4.40	1.39
Germany	2012 ³	0.36 [†]	0.44	1.00
Sweden	2013 ³	0.27 [†]	2.83	0.60
Japan	2000 ⁶	0.17	<0.00	0.44
Poland	2012 ³	0.11 [†]	0.29	0.36
Russia	2013 ³	3.19 [†]	2.22	0.19
New Zealand	1988 ⁴	0.05	1.52	0.19
Canada	1996 ²	1.51	5.10	0.15
Australia	2012 ¹	0.20 to 0.35	0.90 to 1.52	0.03 to 0.05

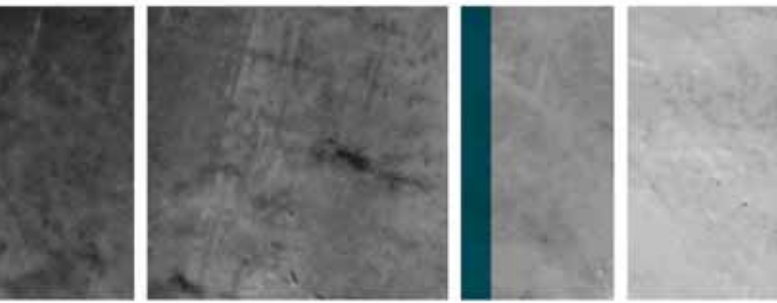
[†]Hunter numbers estimated from digitized plots

¹ Finch et al. (2014), ² Gray et al. (2003), ³ Massei et al. (2015), ⁴ Nugent (1992), ⁵ U.S. Fish & Wildlife Service. (2011), ⁶ Kaji et al. (2010)

2. Methods

2.1 Literature search

Relevant literature items were identified and collated using a five step search. First, the author's personal bibliography management database was searched for articles in which the words "shooting" or "hunting" appeared in the title, abstract or keywords. The online Web of Science Core Collection database was then searched on 4 November 2016 using the terms "shooting OR hunting" and "pest OR overabundant", within topics. The search was limited to items published since 1980. The resulting list of items was refined using the categories of ecology, forestry, biology, zoology, environmental sciences and environmental studies. Time constraints on the project precluded a wider search. Because this project was mainly



concerned with making inferences relevant to the Australian situation, studies that focused on the hunting of uncommon native species, such as cougars (*Puma concolor*) in North America, were excluded.

To uncover grey literature and try to reduce the impact of publication bias, Google Scholar was searched on 4 November 2016 for articles containing the following sets of keywords: “hunting shooting pest”, “hunting shooting overabundant” and “hunting ‘over abundant’ shooting”. Only the first 50 articles returned by each search were used. The Invasive Animals Cooperative Research Centre’s PestSmart Connect online database was searched on 13 November 2016 for documents containing the terms “shooting”, “hunting” or “case study” to identify additional literature directly relevant to Australia. Finally, 13 researchers, managers or representatives of shooting organisations across Australia were emailed or telephoned to ask if they could provide any leads on unpublished reports or evaluations

As the review progressed, several items in the reference list of papers that were identified during the initial formal search were followed up on. Due to the time constraints on this project, these items were limited to those that were likely to provide the strongest levels of inference or new insights that hadn’t been revealed in other items.

2.2 Evaluating effectiveness

In determining whether the shooting operations described in a study could be considered effective, we first asked whether any *a priori* quantifiable management objectives had been set and whether the operation achieved those objectives. We expected that management objectives would be framed in terms of reducing either the damage caused by pest animals or the growth or spread of pest populations. If no objectives were specified, we asked whether any reduction in damage or population growth was reported. We also asked whether studies reported stakeholder satisfaction as a positive outcome because this is also often an important, though rarely stated, management objective.

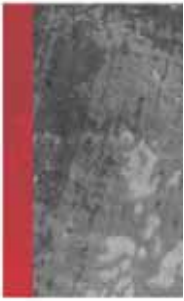
To compare the effectiveness of volunteers and professionals, the nine shooting type categories (Figure 1) were collapsed into five super-categories by removing the lowest level of organisation, land tenure. The super-categories were: government, professional pest control, commercial harvesting, unpaid pest control and unpaid harvesting. The small sample size precluded useful statistical comparisons of differences in effectiveness. Instead, for those studies that stated clear objectives relating to pest or wildlife populations, the results of the studies (objective achieved or not) were tabulated by shooting type. For those studies that did not provide clear objectives, the authors’ opinions of whether operations were effective or not were tabulated by shooting type.

2.3 Factors contributing to effectiveness

For each paper that was considered to have been at least partially effective, key points that authors believed contributed the program’s effectiveness were extracted so that commonalities or unique experiences could be uncovered. Examples of common factors that inhibited effectiveness or efficiency were also sought.

Finally, plots and cross-tabulations were used to check whether effectiveness varied with the following variables:

- taxonomic family of the target population (six levels);
- native or introduced status of the target population (binomial);



- geographic region (six levels);
- geographic extent of operations (1 : 83,500 km²);
- landscape type (four levels); and
- whether other population control tools were used in a broader program (binomial).

The large number of potential variables relative to the number of literature items available precluded any formal analysis of these relationships.

2.4 Cost-effectiveness

For each paper in the sample, details relating to the actual or relative costs of shooting operations were tabulated. All dollar values were corrected for inflation in local currency before being converted to a current (November 2016) Australian dollar value.

2.5 Limitations

This review was conducted over a three week period with a tight deadline. This limited the size of the sample that could be examined effectively, and precluded a wider search of the literature using additional search terms. Consequently, the sample of papers reviewed here may exclude relevant studies that could have provided greater detail and a greater ability to identify patterns in results. The tight deadline also made it very difficult to source useful unpublished material which may have provided additional information unlikely to be reported in peer-reviewed literature. Nonetheless, the sample of papers examined here was selected and evaluated in a transparent and repeatable fashion, and the content represents a diverse range of situations.

3. Results

3.1 Search results

The literature search and filter procedure yielded 36 journal articles or other items describing unique studies published between 1988 and 2016 (Table 1). Three items described manipulative experiments, in which the effects of deliberately manipulating population control methods at different sites were assessed (Hanson et al. 2009, Forsyth et al. 2013, Simard et al. 2013). By their nature, these provided the strongest evidence of causal relationships between shooting operation inputs and population outputs (Platt 1964). A further eight items described comparative mensurative or cross-sectional studies, in which the likely effects different types or intensities of pre-existing population control were compared across a range of sites. The remaining items were all observational in nature, describing the effects of a single trial or management program. Appendix A includes a full list of items.

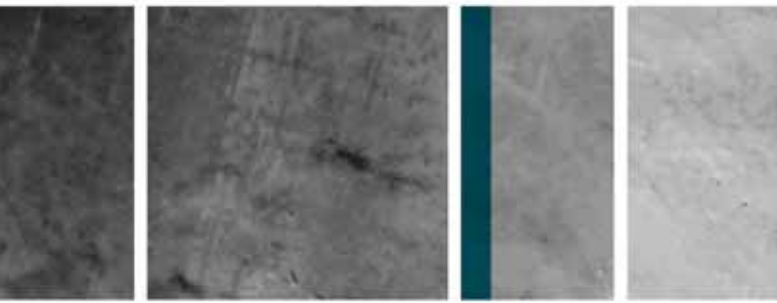


Table 2: Summary of literature search results.

Step	Search location	Date	Number of items returned	New items shortlisted	New items used
1	Endnote	4-Nov-16	133	40	24
2	ISI Web of Science	4-Nov-16	1,427	24	8
3	Google Scholar	4-Nov-16	50 [†]	3	1
4	PestSmart Connect	13-Nov-16	344	4	2
5	Direct requests	throughout project	0	0	0
6	Reference list leads	throughout project	3	3	1

[†]Only the first 50 results were examined for each of three Google Scholar searches. There was substantial overlap in results among search results.

Most studies were from North America and Australasia (Figure 2). Government shooting was the most common shooting type in Australasian studies whereas North Americas, European and the single Asian study were dominated by studies using unpaid hunters (Figure 3). No studies reported on programs or trials of professional shooting operations on public land. Most shooting programs in the sample targeted ungulates (deer n = 16, pigs n = 14, goats n = 2). The remainder targeted carnivores (foxes n = 3, cats n = 2) or macropods (n = 1). Some studies targeted more than one species. Twelve Studies used shooting in a broader strategy with other tools, but most relied entirely on shooting to achieve or maintain reduced population densities or reduced damage (Figure 4).

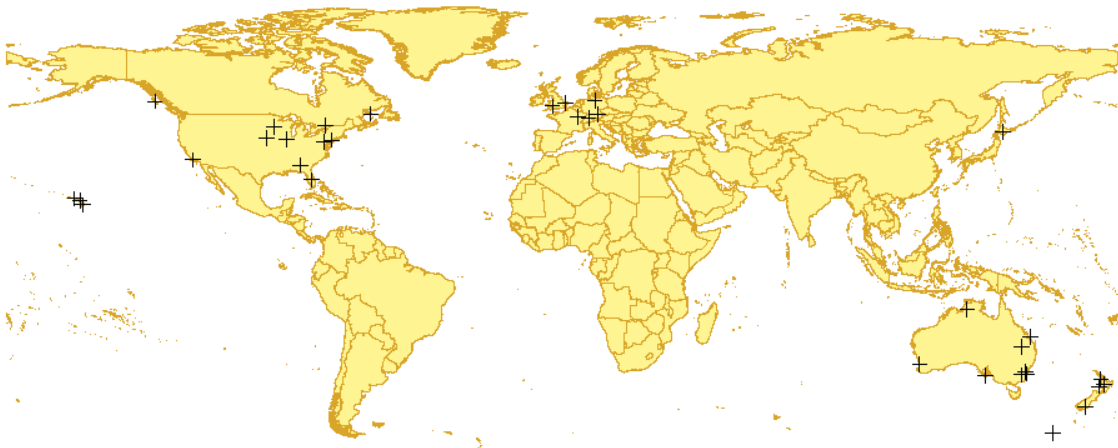


Figure 2: Locations of 36 studies describing ground-based shooting operations or trials.

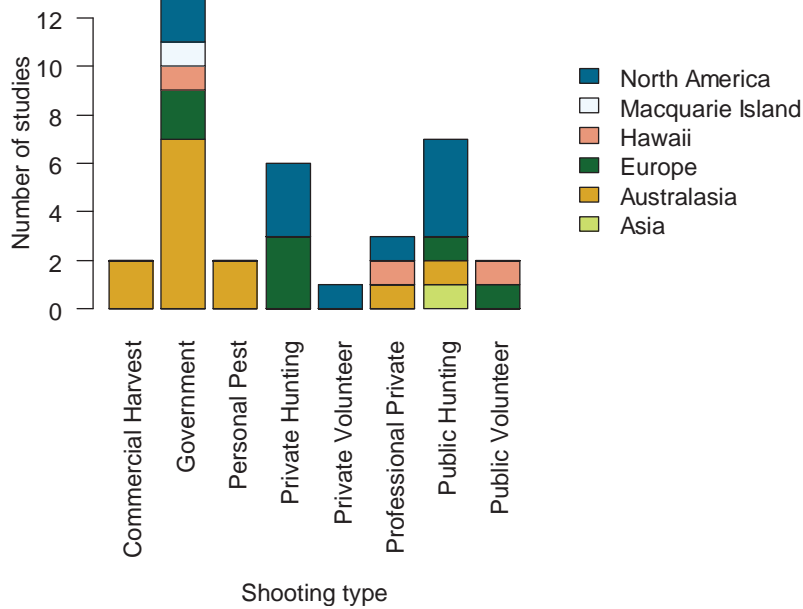
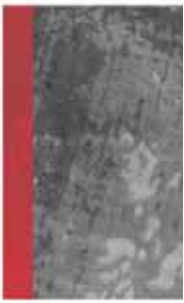


Figure 3: Distribution of 36 studies describing ground-based shooting operations or trials across eight different types of shooting operation and six geographic regions.

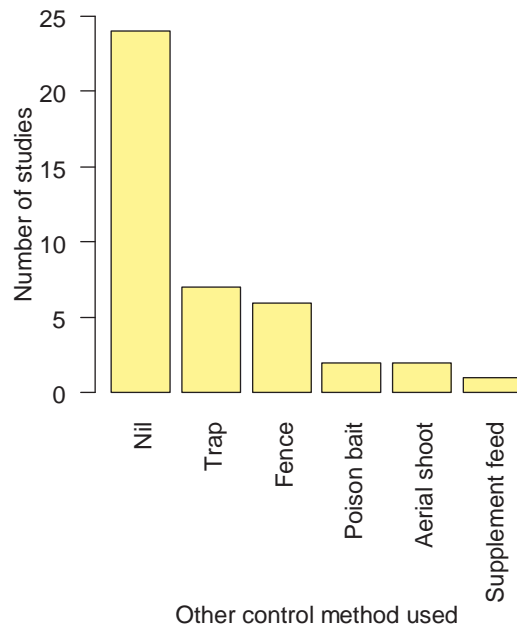
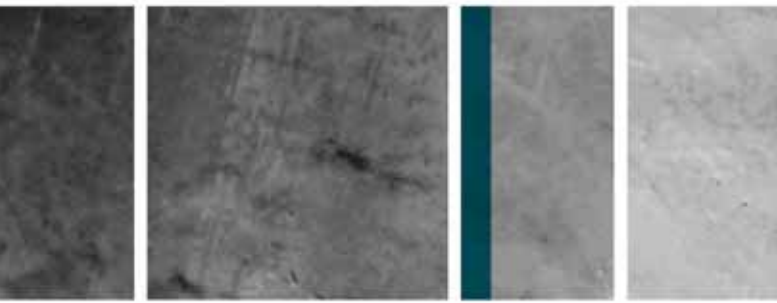


Figure 4: Number of studies that used other population control tools as part of a broader management program that included ground-based shooting. The sum of all values is greater than the sum of the programs examined because some programs used several alternate control tools.



3.2 Effectiveness

Most studies (64%) were quantitatively or qualitatively judged to have been effective, either by achieving *a priori* objectives relating to population or damage reduction, or by achieving a level of population or damage reduction that was considered useful by the authors.

Only 14 studies stated a clear, measurable objective against which success could be judged. Most of these studies involved government shooters. In nine of these cases, the stated objective was eradication of pests from insular systems. Most studies that had clear objectives were either successful or ongoing. Of the 22 studies that did not state a specific objective, most (16) used unpaid shooters, either recreational hunters or volunteers, for at least part of their operations. Twelve reported either a population reduction or an immediate increase in mortality and were considered to have been at least partially successful by the authors. Nine studies reported that target populations or damage did not decline as a result of management (one study did not address the effects of hunting at the population scale).

The proportion of shooting operations or programs that were judged to be effective appeared to be greater for:

- operations that targeted introduced species rather than overabundant natives;
- operations that used government or professional pest controllers rather than unpaid shooters or commercial harvesters;
- operations in which the primary purpose for organizing shooting events was pest control rather than harvesting; and
- programs in which shooting operations were used as part of a broader strategy with other control tools (Figure 5).

Effectiveness did not vary greatly with taxonomic family of the target species, landscape type, average treatment area or geographic region (except for an apparently higher proportion of studies reporting on ineffective programs in Europe and a single report on an ineffective program in Asia)(Figure 6).

Seven key themes emerged from our systematic examination of the literature as contributing to the success of shooting operations. Numbers of studies citing these themes as influential are included in brackets:

1. The use of tools or methods that enhance efficiency (14)
2. A small area of operations (AO, 5)
3. The use of experienced and committed shooters (4)
4. A highly accessible AO (3)
5. Financial incentives for professional or commercial shooters (2)
6. A strong conservation or management ethic in unpaid shooters (2)
7. Favourable environmental or topographical features in the AO (2)

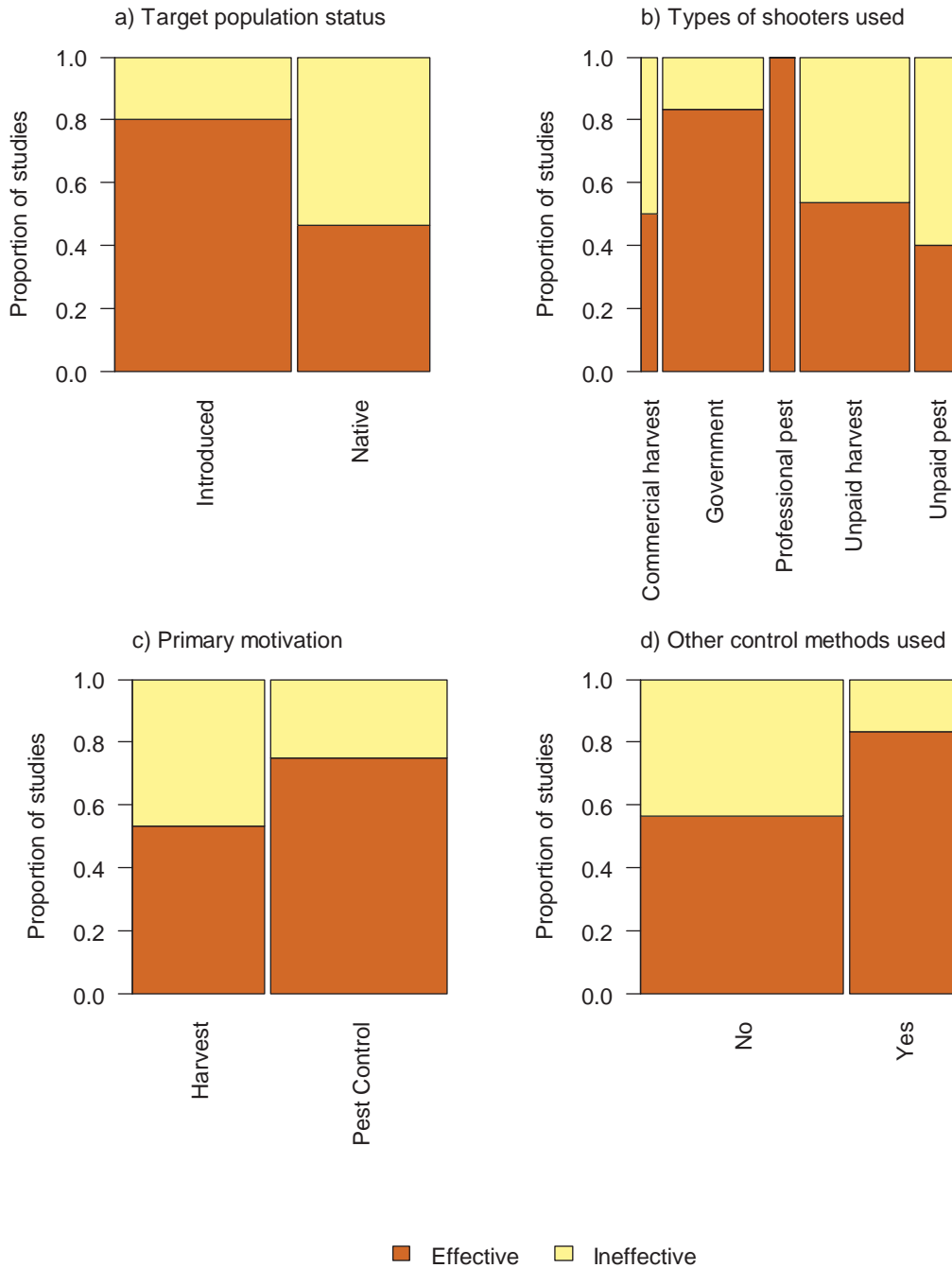
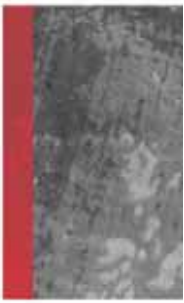


Figure 5: Distribution of shooting program effectiveness split by four different variables in 36 studies of pest or overabundant population management. Width of bars represents the relative number of studies and height of bars represents the proportion of studies deemed to be ineffective or effective.

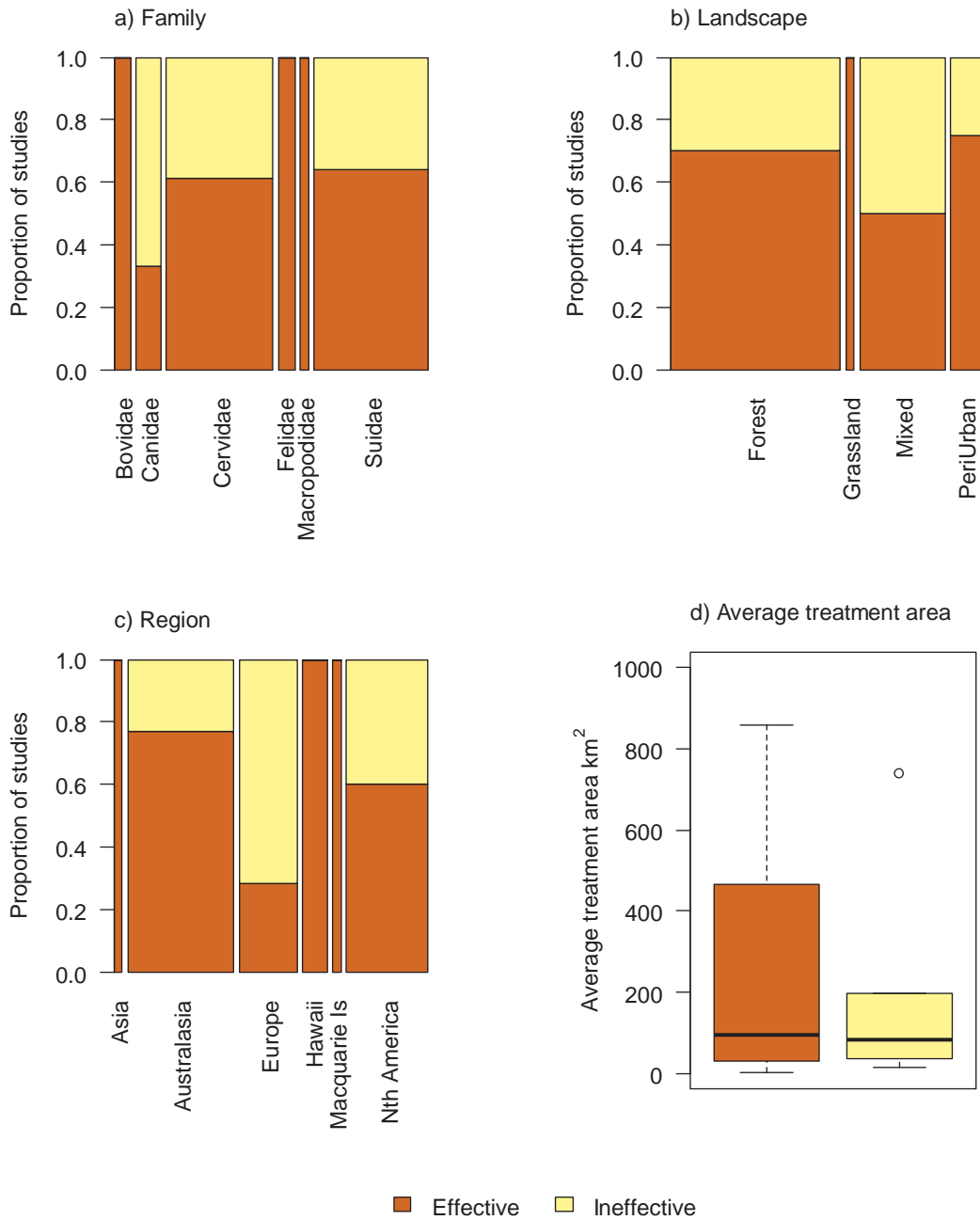
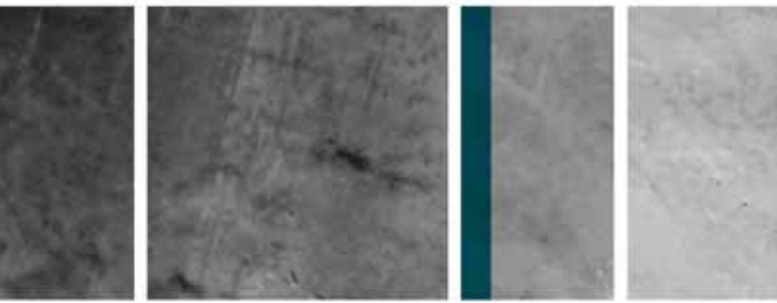
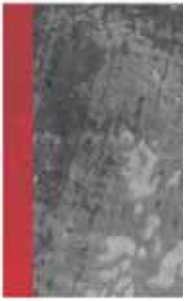


Figure 6: Distribution of shooting program effectiveness split by four different variables in 36 studies of pest or overabundant population management. Three outliers > 1,000 km² are excluded from panel d.



A further seven themes were consistently identified as detracting from the success of operations:

1. The functional response of shooters to declining pest populations (11)
2. Insufficient spatial or temporal coverage (7)
3. The presence of refugia (5)
4. Selective harvesting (4)
5. Low control intensity relative to the population's reproductive capacity (2)
6. Perceived unavailability of tools or methods that enhance efficiency (2)
7. Behavioural adaptation in target populations exposed to repeated persecution (2)

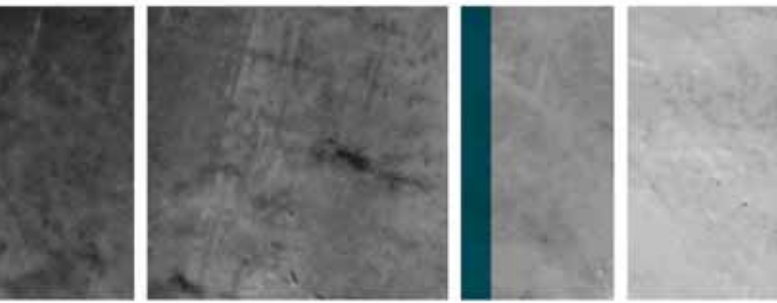
An additional three themes were identified in single studies: lack of support for harvest objectives by shooters, unfavourable vegetation structure in the AO and slow recovery of plants after predation by overabundant herbivores was reduced.

3.3 Cost-effectiveness

Eleven studies in our sample provided information on aspects of absolute or relative cost. This information was generally in the form of average cost per animal killed or estimation of the total cost of a particular program. One study was excluded because it was impossible to separate costs of shooting operations from other control tools used in the program.

Cost per animal killed ranged from \$34 for shooting foxes by spotlight on a farm in eastern Australia (Newsome et al. 2014) to \$428 in current terms for police officers shooting deer over bait or in drives in urban parklands in the US (Doerr et al. 2001)(median cost = \$229 per animal, $n = 6$). The three studies that provided details on cost per animal over time all showed that costs increased as populations declined. Two studies that compared the relative cost of shooting operations to other control tools in Australia reported that shooting was more expensive and probably less effective than poison baiting for pigs or foxes (McIlroy & Saillard 1989, Newsome et al. 2014). The other study that compared costs reported that ground shooting was less expensive than aerial shooting in difficult conditions, even when ground shooting targeted very low population densities (Anonymous 2013).

Two New Zealand studies reported that expected costs of maintaining feral goat or pig densities at acceptable levels were \$876 and \$515 $\text{km}^{-2} \text{ year}^{-1}$, respectively (Forsyth et al. 2003, Krull et al. 2016). However, it was not possible to compare these figures with expected costs of achieving similar results using other control methods such as poison baiting or aerial shooting. Two studies from the United States that reported on the net costs of managing recreational or volunteer shooters on peri-urban public land provided vastly different estimates (mean \$864 $\text{km}^{-2} \text{ year}^{-1}$ for recreational hunters and \$1,501 $\text{km}^{-2} \text{ year}^{-1}$ for volunteers)(Doerr et al. 2001, Williams et al. 2013). The cost of managing recreational hunters would have been about 2.5 times greater if it were not offset by licensing fees (Doerr et al. 2001).



4. Discussion

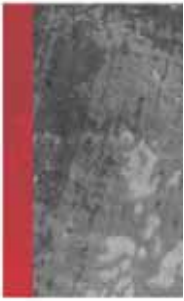
The diversity of shooters, target species and environmental and social contexts in which ground-based shooting has been used makes it difficult to draw generalisations about when, where, how and why shooting can be a useful tool for controlling overabundant animal populations. Nonetheless, there are some patterns across studies that suggest underlying commonalities and contrasts. There are also useful lessons to be learned from individual studies or operations.

4.1 Why do managers use ground shooting?

In the sample of studies we examined, and in the broader range of studies encountered, there appeared to be two main reasons for choosing to use ground shooting for population control. The first was that managers felt that no other options were available or practical. Most of the studies in our sample relied entirely on ground-based shooting. Often, this was because methods such as aerial shooting or poison baiting were thought to be unavailable due to environmental constraints such as dense vegetation (e.g. Forsyth et al. 2003); risks to non-target species (Hanson et al. 2009); regulatory constraints such as restrictions on pesticide use (McLeod et al. 2011); financial constraints (Hanson et al. 2009); or social resistance to other control tools (McLeod et al. 2011). A survey of pest control activities conducted in New South Wales in 2004 indicated that most deer or feral cat control programs in the state used ground shooting because there were few other tools available (West & Saunders 2007). However, a contemporaneous study suggested that trapping was the most commonly used feral cat control tool for biodiversity protection programs in Australia (Reddix et al. 2006).

The second main reason for using ground shooting was to complement other control methods as part of a broader, strategic population management program. For example, ground shooting teams using tracking dogs were essential for completing the eradication of goats and cats from islands after other control methods had greatly reduced population densities (Parkes et al. 2010, Robinson & Copson 2014). The perceived importance of ground shooting as a complementary management tool varied among studies. Several reports indicated that ground shooting alone was ineffective or prohibitively inefficient for sustained population management, but it could be valuable for removing survivors of other control operations or obtaining samples for disease surveillance (McIlroy & Saillard 1989, Caley & Ottley 1995, Newsome et al. 2014). Conversely, other reports indicated that ground shooting was more effective or efficient at reducing populations or damage than other available methods such as aerial shooting (Anonymous 2013), poison baiting and trapping (Domm & Messersmith 1990) or fencing and supplementary feeding (Geisser & Reyer 2004).

Another reason for choosing ground shooting as a population control tool appears to be convenience. This is not commonly reported, but may be widespread. In Australia, convenience is probably common in private pest control, where land managers are able to conduct shooting operations at their convenience, rather than relying on third parties to provide services or materials such as poison baits (Newsome et al. 2014). The convenience factor is also apparent in some uses of commercial or recreational harvesters, where managers believe they are receiving a low cost or free pest control service from a third party (e.g. Gentle & Pople 2013). Convenience may also be important where pre-existing programs provide a means to continue with a 'business as usual' approach. The heavy reliance on recreational hunting for controlling deer populations in North America, for example, has been deeply embedded into the culture of wildlife management and some commentators have argued that it stifles adaptation and improvement (e.g. Rutberg 1997, Peterson & Nelson



2016). The dominance of hunting in North America was evident in our sample of studies (Figure 3).

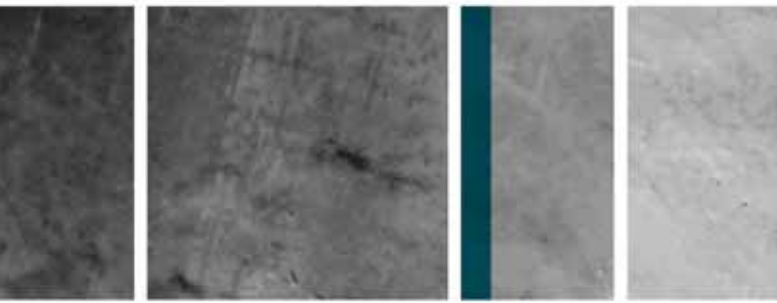
4.2 Problems with assessing effectiveness

There are several difficulties in assessing the effectiveness of shooting programs reported in the literature. Perhaps the greatest and least tractable of these is establishing a consistent benchmark for effectiveness. Few reports provided any clear management objectives that could be measured in terms of population density or damage reduction. Most of those that did were well-resourced and carefully-executed strategic management programs (e.g. Parkes et al. 2010) or manipulative experiments (e.g. Simard et al. 2013). Some reports in the sample judged the effectiveness of shooting operations by the effects that they had on resources such as crops or native vegetation (e.g. Martin & Baltzinger 2002, Hothorn & Müller 2010). While not as meaningful as assessing whether shooting operations reduced damage to a pre-defined acceptable level, these studies are still useful in demonstrating some benefit of control.

The majority of reports we examined based their evaluation of effectiveness on the ability of operations to reduce absolute or relative population density; a program was considered successful if it reduced population density by a detectable amount. It is important to understand how management inputs, such as shooting activities, relate to program outputs, such as population density reductions (Choquenot & Hone 2002), and in many cases, a reduction in density will lead to a reduction in impacts (Hone 2007). However, not all density reductions can be expected to produce useful results. For example, many pest or overabundant populations appear to have threshold densities above which their impacts are unacceptable. Two North American studies in our sample cited a density of < 10 deer km^{-2} as desirable to reduce the impacts of overabundant deer on zoonotic disease transmission, vehicle collisions and landscape damage (Frost et al. 1997, Williams et al. 2013). An Australian analogy is the need to reduce rabbit populations to < 100 rabbits km^{-2} to allow regeneration of vulnerable woody species in many areas (e.g. Mutze et al. 2008, Bird et al. 2012). One study in our sample reported $> 75\%$ reductions in deer density but was considered to have been ineffective because deer densities stabilized above 10 km^{-2} (Williams et al. 2013). Had the authors not been more careful than most in identifying a meaningful objective, this study would have been considered a success.

4.3 Which ground shooting operations were most effective?

Notwithstanding the above limitations, comparisons of studies that were deemed to be effective or ineffective by their authors reveal some contrasts that are worth investigating. The greatest contrast was between situations in which the target species was introduced and those where it was native. Less than 50% of programs targeting native species were considered to have been effective, whereas 80% of those targeting introduced species were effective (Figure 5a). This could seem counter-intuitive; introduced, invasive species are often perceived as being more robust or resilient to persecution than native species because they tend to have high reproductive potential and are often released from predators, parasites or diseases of their native range (Conway 1976, Begon et al. 1996). However, all but one program targeting native species occurred in North America, Europe or Asia, and most of these relied solely on shooting by recreational hunters or volunteers. The native/introduced contrast is therefore partially confounded by differences in the types of shooter used and whether other shooting operations were integrated into a broader management strategy that also used other population control tools. Both of these variables were also associated with



differences in effectiveness (Figure 5b, 5d), and may have been more important determinants of program effectiveness than the native or introduced status of the target species *per se*.

4.4 What factors contributed to effectiveness?

The most useful foundation for understanding where, when and how shooting programs are most likely to be effective comes from the identification of common themes across our sample of studies. The factor most frequently-cited as contributing to the success of shooting operations was the use of methods or equipment that enhanced shooters' efficiency. Tools or methods that enhance efficiency allow shooters to kill more animals per unit of time than they would otherwise be able to, and hence to have a greater impact on population mortality. Furthermore, the number of animals killed by a predator (e.g. a shooter) per unit of effort generally declines if animals are removed from the population faster than they are replaced, a concept known as the functional response (Holling 1959). Harvest-oriented shooters, such as commercial harvesters or recreational hunters, will usually have a threshold on this curve of diminishing returns below which further effort is unrewarding (e.g. Gentle & Pople 2013, Williams et al. 2013). If shooters can increase their efficiency (i.e. their harvest rate), they will increase the slope of their functional response curve, thereby allowing them to continue harvesting animals at lower population densities than would otherwise have been possible (Figure 7). Efficiency can be improved by increasing the rate at which shooters encounter animals or by increasing the proportion of encounters that are converted to kills.

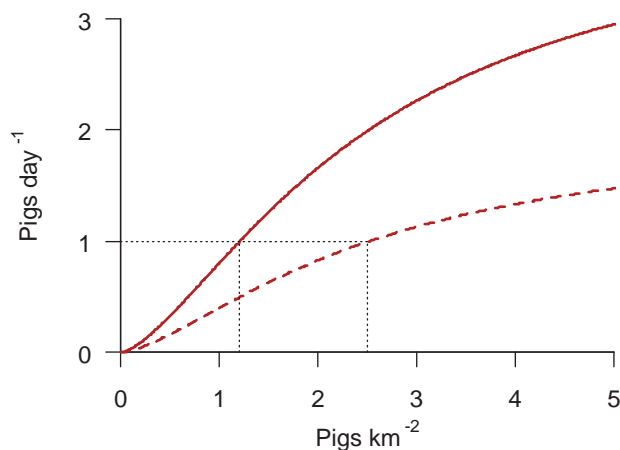
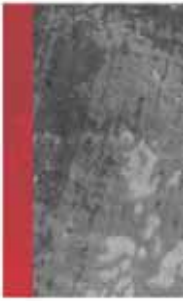


Figure 7: Hypothetical functional response curves for a recreational feral pig hunter with two different searching efficiencies. The solid curve represents the more efficient searching pattern, which allows the hunter to find and kill more pigs per hunting day. Dotted vertical lines show the minimum population density at which the hunter is able to kill one pig per day (1.2 pigs km⁻² for the more efficient searching pattern and 2.5 pigs km⁻² for the less efficient pattern)(adapted from Bengsen & Sparkes 2016).

One third of the studies in our sample used dogs to increase the success of shooters targeting cats (e.g. Robinson & Copson 2014), deer (e.g. Godwin et al. 2013), goats (Forsyth et al. 2003) or pigs (e.g. Parkes et al. 2010). Dogs that locate, track or pursue animals can enhance efficiency by increasing the rate at which shooters encounter animals. Dogs that bail or hold animals can further enhance efficiency by increasing the proportion of encountered animals



that are killed. Bailing and holding (lugging) dogs are commonly used by unpaid and commercial hunters targeting pigs. However, the use of dogs in this way has been criticised by animal welfare or rights organisations and others on the grounds that it causes unnecessary suffering to both pigs and dogs (e.g. Shoebridge & Hopley 2014, RSPCA 2016), and the use of lugging dogs is illegal in Victoria. Using or condoning the use of bailing or lugging dogs in operations targeting feral pigs could therefore expose those operations to social risk. Dogs can also hinder control programs when escaping animals learn to avoid shooters (McIlroy & Saillard 1989).

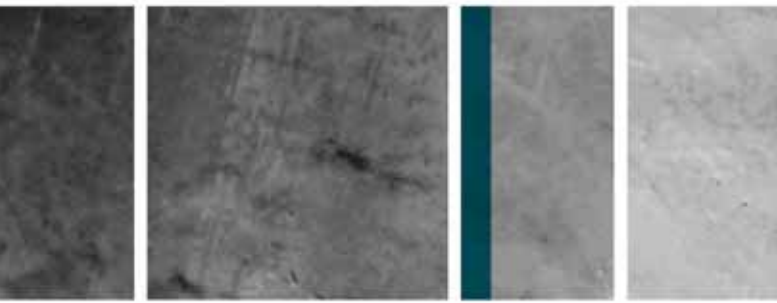
The efficiency of ground shooting operations can also be influenced by the method used to find animals. Most of the shooting operations used in our sample of studies could be classified into one of five search types, although different studies used different labels for the same activity:

- Searching for animals on foot, with or without the assistance of dogs (stalking)
- Searching for animals from a vehicle, usually at night with a spotlight (spotlighting)
- Passive lying in wait, often over a feeding station (stand hunting)
- Lying in wait for animals driven by beaters, with or without dogs (drives)
- Opportunistic shooting.

No single search type was consistently reported as being more effective than any other. Their relative effectiveness probably varied depending on the situation, although no studies reported that opportunistic shooting improved efficiency. Two studies reported that drives were more efficient than stand hunting for deer or pigs (Frost et al. 1997, Keuling et al. 2010). However, other studies have found that harvest-oriented shooters using stands or stalking are often more selective than those using drives (e.g. Novak et al. 1991, Martínez et al. 2005), so differences in efficiency in some studies may be partly attributable to stand shooters passing up opportunities to kill animals. This also suggests that stand shooting may not be useful for ungulate management programs that use harvest-oriented shooters, unless systems are established to circumvent selectivity (e.g. Boulanger et al. 2012). Selective harvest-oriented shooters tend to target older male ungulates, whereas females and juveniles tend to make the greatest contribution to population growth (e.g. Toigo et al. 2008).

Spotlighting is widely used to target foxes and rabbits in Australia (e.g. Coman 1988) and it can reduce pest populations if applied with sufficient intensity (McLeod et al. 2011). Spotlighting has also been reported to be more efficient than stand shooting or drives for shooting deer in North America (Frost et al. 1997), and has been identified as the preferred primary ground shooting method for controlling deer in several Australian management plans or strategies (e.g. Masters 2009, Williams 2009). However, it has been repeatedly dismissed as an ineffective population control tool in its own right because it is generally too inefficient to be able to achieve meaningful population reductions: published examples of kills per unit effort for foxes in eastern Australia range from 0.24 foxes hr⁻¹ (Coman 1992) to 0.78 foxes hr⁻¹ (Fleming 1997, Newsome et al. 2014). Furthermore, spotlighting is limited to areas with good visibility and vehicle access.

Searching and killing efficiency can also be enhanced by using specialist equipment such as high performance thermal imaging (TI) scopes and sound suppressors (referred to as silencers under NSW firearms regulations). A wide range of TI equipment is now becoming available for general consumption, including rifle-mounted scopes. Many of these devices can improve a shooter's ability locate target animals. When combined with sound suppressors and

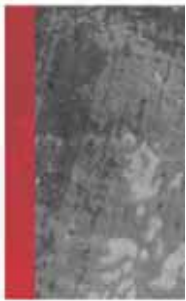


appropriate ammunition to reduce sonic disturbance, whole groups of animals can be shot at once (G. Eccles, NSW OEH, 2016 NSW Vertebrate Pest Symposium, Orange, 26 October 2016). The use of TI scopes and suppressors can also reduce the risk of disturbing the public, thereby allowing nocturnal shooting operations to be conducted at locations where they have previously been unavailable. Despite a recent expansion of the conditions under which shooters can apply to acquire a suppressor in NSW, firearms regulations in Australian states place heavy restrictions on their possession and use, and they remain largely limited to professional and government operations.

The next most frequently cited aid to effectiveness, after improving efficiency, was the use of small AO's in which operations could be concentrated and population recovery through immigration from areas outside the AO could be minimised. This is exemplified by the eradication of feral cats from a small (1 km²) island on the Great Barrier Reef (Domm & Messersmith 1990). Most operations, however, had to deal with larger AO's and more permeable borders. Four feral pig eradication programs used fencing to divide large areas into smaller management units that could be more easily and decisively handled (Hone & Stone 1989, Parkes et al. 2010, Barron et al. 2011, Burt et al. 2011). A feral goat eradication program on Kangaroo Island used unfenced management units based on natural barriers and road access to manage shooting and monitoring effort. These management units were important for sustaining the focus and activity of volunteer shooters as populations and harvest rates declined (N. Markopoulos, Kangaroo Island Natural Resources Management Board, pers. comm. 14 November 2016). Similarly, an evaluation of a long-running feral goat management program in New Zealand described the introduction of management units as a crucial action because it allowed managers to direct recreational hunters to locations where their activities could be most useful, in a timely manner (Forsyth et al. 2003). While manageable AO's can be important, failure to conduct operations over a sufficient spatial and temporal extent to minimise population recovery through immigration was identified as detracting from some studies in our sample (McLeod et al. 2011, Engeman et al. 2014, Newsome et al. 2014).

Apart from size, other geographic traits that were thought to be important included accessibility to shooters, particularly for harvest-oriented shooters, and features that provided high search and kill efficiencies such as flat terrain and sparse low-level vegetation. Three main aspects of accessibility were apparent: the remoteness of sites from commercial harvesting processors (e.g. Gentle & Pople 2013); remoteness of sites from populations of recreational hunters (e.g. Nugent 1988, Martin & Baltzinger 2002); and the ability of shooters to access all areas within an AO (e.g. Nugent 1988, Domm & Messersmith 1990, Foster et al. 1997).

Commercial harvesting of feral pigs in Australia relies on independent harvesters returning pig carcasses to a processing unit, known as a chiller, nightly. Harvesters' travel and opportunity costs increase as the distance between harvesting site and chiller increases, and there will generally be a threshold distance beyond which harvesting becomes uneconomical and a rational harvester will cease operations. The value of this threshold distance will vary, depending on conditions such as prices paid at the chiller, the number of pigs harvested per trip, travel costs and a harvester's minimum acceptable profit (Choquenot et al. 1995). The spatial concentration of chillers in southern Queensland and northern New South Wales led Gentle and Pople (2013) to conclude that commercial harvesting alone could not be relied on to suppress feral pig populations because there were too many large areas where pigs would not be targeted. These areas could provide a source of immigrants to compensate for harvest mortality in other areas.



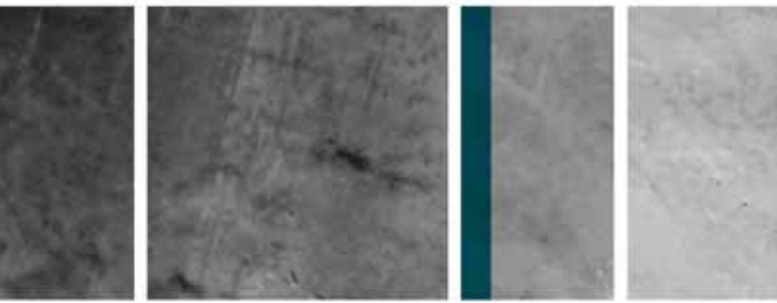
A similar process appears to be common with recreational hunters. Studies in our sample showed that few hunters travelled more than 100 km to hunt deer at a site on New Zealand's South Island (Nugent 1988), and that hunting was able to protect plantation timber regeneration from deer in areas that were readily accessed by road, but not in areas that were only accessible to hunters by air or sea (Martin & Baltzinger 2002). Studies beyond our sample have also reported similar effects of remoteness on and the spatial distribution of hunting pressure, population mortality (e.g. Stoner et al. 2013) and on hunters' preferences (e.g. Botton et al. 2003).

Accessibility also plays out at a smaller scale. Many studies have shown that harvest-oriented shooters have tended to concentrate their activity within areas that are most easily accessed and that hunting mortality diminishes with increasing distance from roads and flat ground (e.g. Brøseth & Pedersen 2000, Lebel et al. 2012). In our sample, Nugent (1988) found that hunters had little impact on deer in forests at distances farther than 1.5 km from access points. Simard et al. (2013) also reported that most deer killed by hunters were close to roads, and that large tracts of unfragmented forest probably protected large proportions of target populations from hunters. Some programs conducted in challenging terrain used helicopters to ferry hunters and equipment to remote locations to overcome these problems (e.g. Parkes et al. 2010, Burt et al. 2011). Foster et al. (1997) found that deer were most effectively harvested in areas with small, isolated forest patches that were easily accessible to hunters, and that suburban areas probably provided refuge. Other studies also reported that urban and suburban areas provided refugia that limited the ability of hunting and shooting operations to target all individuals in a population (Hygnstrom et al. 2011, Williams et al. 2013). Animals that are protected by refugia from harvesting or culling will reduce the level of population control that can be achieved in the first instance and can provide an important source of breeding stock for population recovery.

Most studies in our sample identified physical, demographic or environmental traits that were important contributors to the effectiveness of shooting operations. However, social and economic issues were also prominent. Two studies provided clear examples showing that shooting programs benefited from having experienced and committed shooters who were familiar with the target population and the area and method of operations:

- A core group of frequent recreational hunters, comprising 3.5% of the hunter population, was responsible for more than 50% of all deer kills at a site in New Zealand (Nugent 1988),
- Professional hunters targeting feral pigs in New Zealand were more efficient after their first foray into a new management area (Krull et al. 2016).

Other studies indicated that shooter experience and commitment was an important contributor to a program's effectiveness (Parkes et al. 2010, Barron et al. 2011) or that the lack of these traits probably reduced effectiveness (Burt et al. 2011). Moreover, prolonged involvement of individual harvest-oriented shooters in a program can help build a conservation or management ethic. This can enhance their efficacy by reducing their reluctance to take actions that are perceived as detrimental to the maintenance of future harvest opportunities, such as reducing populations to low densities or taking age and sex classes that make the greatest contribution to population growth (Hygnstrom et al. 2011, Williams et al. 2013). A reluctance of hunters to take females was thought to be a major barrier to effectiveness in some programs targeting deer (Martin & Baltzinger 2002, Kaji et al. 2010) and pigs (Toigo et al. 2008). This type of selective harvesting to protect breeding stock has also been reported in Australia (Hall & Gill 2005) and is consistent with codes of conduct promulgated by some Australian hunting organisations (e.g. Australian Deer Association 2014).

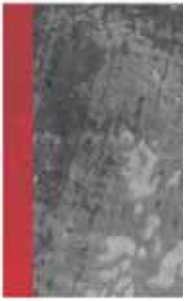


Ground shooting can be a particularly labour-intensive and expensive form of pest animal control, so it is not surprising that many studies in our sample examined the costs associated with shooting operations. Cost and revenue estimates of various components of operations can be used to evaluate alternate control methods or strategies, prioritise investment and generate hypotheses about ways to improve effectiveness (e.g. Nugent & Choquenot 2004, Cooke et al. 2010). The two studies in our sample that combined cost estimates with population models to estimate the investment required to contain pest populations or damage to acceptable levels both reported substantial ongoing costs for sustained management (Forsyth et al. 2003, Krull et al. 2016). Several North American studies reported on programs that tried to avoid or reduce the costs of retaining staff or professional controllers for ongoing operations by using volunteer shooters or hunters. Some of these reported similar costs per animal to government shooting but lower costs per animal than other control tools such as trapping (Doerr et al. 2001, Hygnstrom et al. 2011). Conversely, an Australian study found that spotlight shooting to control foxes was likely to be more costly and less effective than poison baiting (Newsome et al. 2014). Other studies showed that there can still be substantial costs associated with managing volunteers or hunters (Williams et al. 2013), even when costs are partially offset by charging licence fees to hunters (Doerr et al. 2001, Hygnstrom et al. 2011). The cumulative cost of these expenses could potentially outweigh the cost of professional control if differences in efficiency between professional and unpaid shooters mean that greater input is needed from unpaid shooters than would be needed from professionals in the long term. Careful construction of contracts and milestones for professional shooters can provide efficiency incentives that can help to minimise the duration of shooting operations (Parkes et al. 2010).

Commercial harvesting provides another option that can be available to reduce the cost of shooting operations in some situations. As previously noted, the ability of commercial harvesting to knockdown and suppress populations over sufficiently large AO's is limited by economic constraints (Gentle & Pople 2013). Furthermore, feral pig harvesters rarely took a large enough proportion of the population to cause a decline in population growth (Gentle & Pople 2013), presumably because the harvesting rate at which operations became unprofitable was greater than the rate needed to reduce populations to densities at which growth was suppressed. However, it could be possible to reduce these constraints by increasing the price paid for carcasses (Ramsay 1994). Modeling studies indicate that subsidised harvesting should be more cost-effective than government culling in some situations (e.g. Nugent & Choquenot 2004). This was demonstrated in a study of commercial kangaroo harvesting in a small, insular system. Kangaroo population density was reduced to desired levels by paying subsidies to a commercial harvester to continue harvesting when it would otherwise have been unprofitable. This greatly reduced the operational cost of the program and the cost per animal, relative to what would otherwise have been expected (Mawson et al. 2016). Commercial harvesting can also help to overcome community resistance to control operations that would otherwise use a 'shoot to waste' policy (Mawson et al. 2016), as can the donation of carcasses to organisations that can use them for public benefit (Frost et al. 1997).

4.5 Limitations of ground shooting

The preceding discussion has shown that there are many situations when ground shooting can be a useful, and sometimes crucial, method for controlling overabundant or pest animal populations. However, the effectiveness of shooting operations is clearly constrained by a wide range of biophysical, social and economic factors. Perhaps the greatest overall constraint is the low efficiency of ground shooting compared to other control methods, such



as poison baiting and aerial shooting, that can produce a large population reduction in a short time under favourable conditions (e.g. Saunders 1993, Thompson & Fleming 1994). The low efficiency of ground shooting has at least two important consequences:

- 1) Slow, drip-feed mortality from shooting operations is often offset by increased reproduction or immigration. This is particularly important for species that can increase their reproductive output to high levels in response to inefficient harvest mortality, such as feral pigs and some deer species (e.g. Hanson et al. 2009, Kaji et al. 2010, Servanty et al. 2011).
- 2) Diminishing returns on increased shooting effort dictate that it will often be very expensive, or practically impossible, to achieve desired levels of population or damage reduction using shooting alone (e.g. Krull et al. 2016). This is especially relevant when harvest-oriented or unpaid shooters are used because they are likely to abandon operations when the harvest rate declines to unrewarding levels, which will often be greater than the harvest levels required to meet management objectives (e.g. Gentle & Pople 2013, Williams et al. 2013).

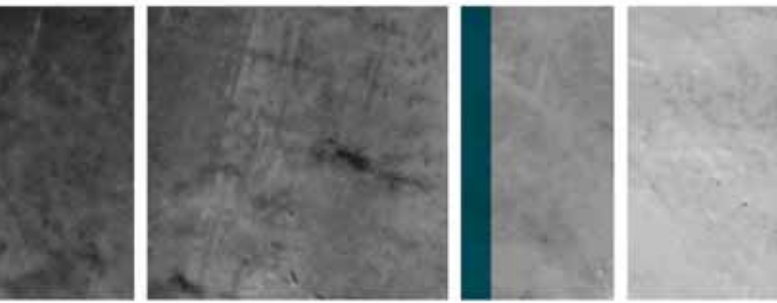
The limiting effects of low efficiency are likely to be strongest in widespread, well-established pest populations that occur at densities close to environmental carrying capacity. These populations can be expected to have a greater capacity to compensate for increased mortality from shooting operations by increasing reproductive output, survival or immigration (Bengsen & Sparkes 2016).

Ground-based shooting operations are likely to be most beneficial when they target spatially-restricted populations that occur at densities well below carrying capacity, in environments that offer little refuge. Examples include populations that have been recently established, that are restricted to insular systems, or that have been reduced by other control methods or environmental conditions. Reliance solely on harvest-oriented shooters is potentially risky in these situations because the harvest rates required to contain the target population within a “predator pit” (sensu Walker & Noy-Meir 1982) may be lower than those at which continued effort is unrewarding. Furthermore, obtaining sufficient volunteer shooters or recreational hunters to maintain useful hunting pressure has often been challenging in North America and Europe (e.g. Simard et al. 2013, Massei et al. 2015), where hunter populations occur at much greater densities than in Australia (Bengsen et al. 2016).

5. Conclusions and recommendations

Ground-based shooting has been used in activities aiming to reduce pest animal densities and impacts in Australia since the earliest years of European settlement. The use of ground shooting is likely to increase in coming years as technological advances and a growing population of recreational hunters broaden the scope of situations in which it can be used. However, there are major limitations on the ability of ground shooting operations to contribute to pest management objectives, and poor application of ground shooting methods can potentially cause more harm than good. Shooting programs and operations examined in this review tended to fall along a continuum between:

- 1) Well planned and resourced programs with clear objectives that were designed to maximize efficiency and generate reliable information that could be used to improve future iterations, and
- 2) Ad hoc programs that relied on convenient resources and assessed their efficacy in terms of whether they achieved a noticeable reduction in pest activity or an increase in participant satisfaction.



Managers considering the use of ground shooting to help control pests should strive to place their operations towards the first end of this continuum by:

- Carefully considering whether ground shooting is actually the best method available for their purposes, and what types of shooting will be most useful;
- Establishing clear, meaningful and measurable objectives to allow for performance assessment, operational learning and continuous improvement;
- Ensuring that operations have adequate financial and human resources (numbers and talent) for the duration of the program to develop and execute operations that maximize efficiency, minimize risks, and are able to suppress populations to densities necessary to achieve desired outcomes;
- Integrating shooting operations with other control methods where appropriate.

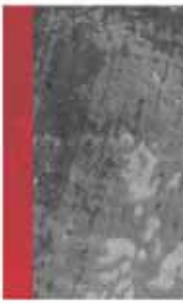
Ground shooting can often appear to offer a simple solution to pest management problems, but the studies reviewed here show that that is rarely the case. In some cases, a quick response to an emerging problem is required. However, proper investment of time and effort before commencing operations will often reduce the risk of management programs developing into ineffectual, expensive and cumbersome sustainable harvesting programs.

Acknowledgements

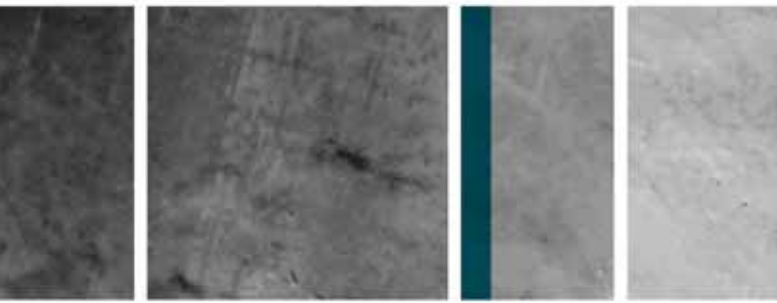
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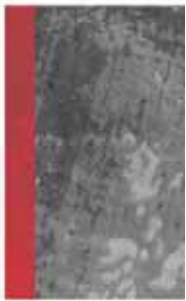
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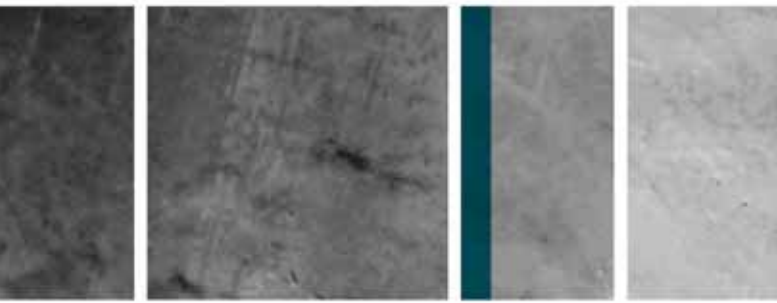
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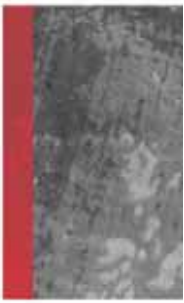
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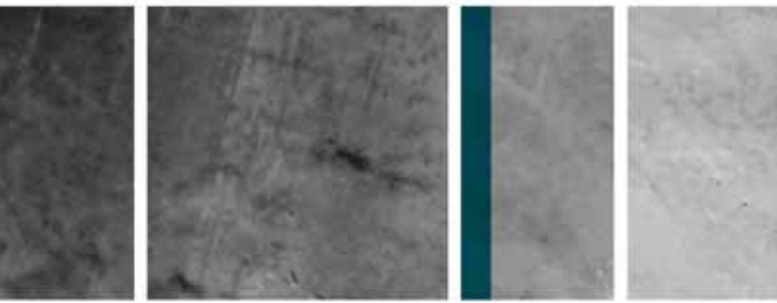
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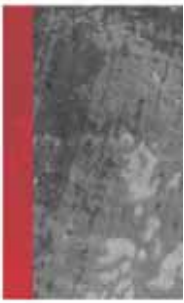
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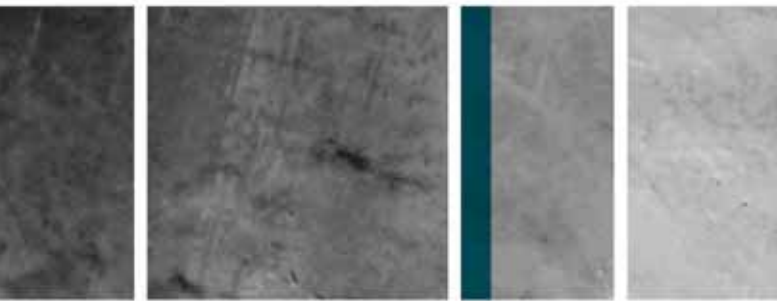


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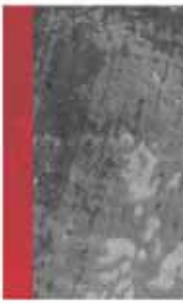


Appendix A: Sample items

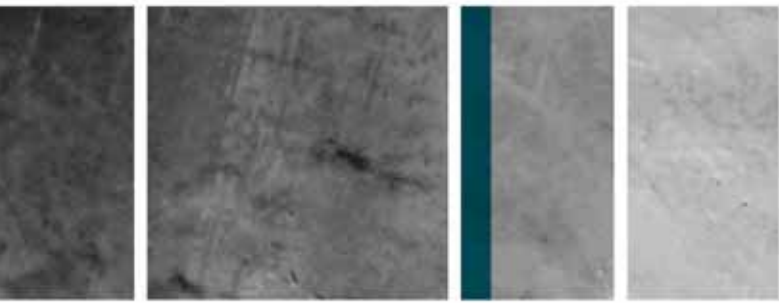
Publication	Type of shooting	Species
Anonymous (2013) Case study: feral deer eradication on Kangaroo Island. PestSmart Toolkit Publication	Government	<i>Dama dama</i>
Anonymous (2013) Case study: feral goat eradication on Kangaroo Island. PestSmart Toolkit Publication	Government	<i>Capra hircus</i>
Baker, P. J., & Harris, S. (2006) Does culling reduce fox (<i>Vulpes vulpes</i>) density in commercial forests in Wales, UK? European Journal of Wildlife Research	Public Volunteer, Personal Pest	<i>Vulpes vulpes</i>
Barron, M. C.; Anderson, D. P.; Parkes, J. P.; Ohukani'ohi'a Gon, S. M. O (2011) Evaluation of feral pig control in Hawaiian protected areas using Bayesian catch-effort models. New Zealand Journal of Ecology	Professional Private	<i>Sus scrofa</i>
Burt, M. D., Miller, C., & Souza, D. (2011) The use of volunteer hunting as a control method for feral pig populations on O'ahu, Hawai'i. Island Invasives: Eradication and Management	Public Volunteer	<i>Sus scrofa</i>
Caley, P., & Ottley, B. (1995) The effectiveness of hunting dogs for removing feral pigs (<i>Sus scrofa</i>). Wildlife Research	Personal Pest	<i>Sus scrofa</i>
Doerr, ML; McAninch, JB; Wiggers, EP (2001) Comparison of 4 methods to reduce white-tailed deer abundance in an urban community. Wildlife Society Bulletin	Government, Public Hunting	<i>Odocoileus virginianus</i>
Domm, S., & Messersmith, J. (1990) Feral cat eradication on a Barrier Reef island, Australia. Atoll Research Bulletin	Government	<i>Felis catus</i>
Engeman, R., Hershberger, T., Orzell, S., Felix, R., Killian, G., Woolard, J., Cornman, J., Romano, D., Huddleston, C., Zimmerman, P., Barre, C., Tillman, E., & Avery, M. (2014) Impacts from control operations on a recreationally hunted feral swine population at a large military installation in Florida. Environmental Science and Pollution Research	Public Hunting	<i>Sus scrofa</i>
Forsyth, DM; Hone, J; Parkes, JP; Reid, GH; Stronge, D (2003) Feral goat control in Egmont National Park, New Zealand, and the implications for eradication. Wildlife Research	Government, Public Hunting	<i>Capra hircus</i>
Forsyth, DM; Ramsey, DSL; Veltman, CJ; Allen, RB; Allen, WJ; Barker, RJ; Jacobson, CL; Nicol, SJ; Richardson, SJ; Todd, CR (2013) When deer must die: large uncertainty surrounds changes in deer abundance achieved by helicopter- and ground-based hunting in New Zealand forests. Wildlife Research	Government	<i>Cervus elaphus</i> , <i>Cervus nippon</i>
Foster, J. R., Roseberry, J. L., & Woolf, A. (1997) Factors influencing efficiency of white-tailed deer harvest in Illinois. Journal of Wildlife Management	Public Hunting	<i>Odocoileus virginianus</i>
Frost, H. C., Storm, G. L., Batcheller, M. J., & Lovallo, M. J. (1997) White-tailed deer management at Gettysburg National Military Park and Eisenhower National Historic Site. Wildlife Society Bulletin	Government, Public Hunting	<i>Odocoileus virginianus</i>



Publication	Type of shooting	Species
Geisser, H., & Reyer, H.-U. (2004) Efficacy of hunting, feeding, and fencing to reduce crop damage by wild boars. <i>Journal of Wildlife Management</i>	Private Hunting	<i>Sus scrofa</i>
Gentle, M., & Pople, A. (2013) Effectiveness of commercial harvesting in controlling feral-pig populations. <i>Wildlife Research</i>	Commercial Harvest	<i>Sus scrofa</i>
Godwin, C; Schaefer, JA; Patterson, BR; Pond, BA (2013) Contribution of dogs to white-tailed deer hunting success. <i>Journal of Wildlife Management</i>	Public Hunting	<i>Odocoileus virginianus</i>
Hanson, L. B., Mitchell, M. S., Grand, J. B., Jolley, D. B., Sparklin, B. D., & Ditchkoff, S. S. (2009) Effect of experimental manipulation on survival and recruitment of feral pigs. <i>Wildlife Research</i>	Public Hunting	<i>Sus scrofa</i>
Hone, J., & Stone, C. P. (1989) A comparison and evaluation of feral pig management in two National Parks. <i>Wildlife Society Bulletin</i>	Government, Public Hunting	<i>Sus scrofa</i>
Hothorn, T., & Müller, J. (2010) Large-scale reduction of ungulate browsing by managed sport hunting. <i>Forest Ecology and Management</i>	Private Hunting	<i>Capra hircus</i>
Hygnstrom, SE; Garabrandt, GW; Vercauteren, KC (2011) Fifteen Years of Urban Deer Management: The Fontenelle Forest Experience. <i>Wildlife Society Bulletin</i>	Private Hunting	<i>Odocoileus virginianus</i>
Kaji, K; Saitoh, T; Uno, H; Matsuda, H; Yamamura, K (2010) Adaptive management of sika deer populations in Hokkaido, Japan: theory and practice. <i>Population Ecology</i>	Public Hunting	<i>Cervus nippon</i>
Keuling, O., Lauterbach, K., Stier, N., & Roth, M. (2010) Hunter feedback of individually marked wild boar <i>Sus scrofa</i> L.: dispersal and efficiency of hunting in northeastern Germany. <i>European Journal of Wildlife Research</i>	Private Hunting	<i>Sus scrofa</i>
Krull, C. R., Stanley, M. C., Burns, B. R., Choquenot, D., & Etherington, T. R. (2016) Reducing wildlife damage with cost-effective management programmes. <i>PLoS One</i>	Professional Pest	<i>Sus scrofa</i>
Martin, J.-L., & Baltzinger, C. (2002) Interaction among deer browsing, hunting, and tree regeneration. <i>Canadian Journal of Forest Research</i>	Private Hunting	<i>Odocoileus hemionus</i>
Mawson, PR; Hampton, JO; Dooley, B (2016) Subsidized Commercial Harvesting for Cost-effective Wildlife Management in Urban Areas: A Case Study with Kangaroo Sharpshooting. <i>Wildlife Society Bulletin</i>	Commercial Harvest	<i>Macropus fuliginosus</i>
McIlroy, J. C., & Saillard, R. J. (1989) The effect of hunting with dogs on the numbers and movements of feral pigs, <i>Sus scrofa</i> , and the subsequent success of poisoning exercises in Namadgi National Park, ACT. <i>Australian Wildlife Research</i>	Government	<i>Sus scrofa</i>
McLeod, L. J., Saunders, G., & Miners, A. (2011) Can shooting be an effective management tool for foxes? Preliminary insights from a management program. <i>Ecological Management & Restoration</i>	Professional Private	<i>Vulpes vulpes</i>
Newsome, TM; Crowther, MS; Dickman, CR (2014) Rapid recolonisation by the European red fox: how effective are uncoordinated and isolated control programs? <i>European Journal of Wildlife Research</i>	Personal Pest	<i>Vulpes vulpes</i>
Nugent, G (1988) Successful control of fallow deer by recreational hunters in the Blue Mountains, Otago. <i>New Zealand Journal of Forestry Science</i>	Public Hunting	<i>Dama dama</i>



Publication	Type of shooting	Species
Parkes, J. P., Ramsey, D. S. L., Macdonald, N., Walker, K., McKnight, S., Cohen, B. S., & Morrison, S. A. (2010) Rapid eradication of feral pigs (<i>Sus scrofa</i>) from Santa Cruz Island, California Biological Conservation	Professional Private	<i>Sus scrofa</i>
Robinson, S. A., & Copson, G. R. (na) Eradication of cats (<i>Felis catus</i>) from subantarctic Macquarie Island. Ecological Management & Restoration	Government	<i>Felis catus</i>
Servanty, S., Gaillard, J. M., Ronchi, F., Focardi, S., Baubet, E., & Gimenez, O. (2011) Influence of harvesting pressure on demographic tactics: implications for wildlife management. Journal of Applied Ecology	Government, Public Hunting	<i>Sus scrofa</i>
Simard, MA; Dussault, C; Huot, J; Cote, SD (2013) Is hunting an effective tool to control overabundant deer? A test using an experimental approach. Journal of Wildlife Management	Private Hunting	<i>Odocoileus virginianus</i>
Toïgo, C., Servanty, S., Gaillard, J.-M., Brandt, S., & Baubet, E. (2008) Disentangling natural from hunting mortality in an intensively hunted wild boar population. Journal of Wildlife Management	Public Hunting	<i>Sus scrofa</i>
Wäber, K., Spencer, J., & Dolman, P. M. (2013) Achieving landscape-scale deer management for biodiversity conservation: The need to consider sources and sinks. Journal of Wildlife Management	Government, Public Hunting, Private Hunting	<i>Capreolus capreolus</i> , <i>Muntjac reevesi</i>
Williams, SC; DeNicola, AJ; Almendinger, T; Maddock, J (2013) Evaluation of organized hunting as a management technique for overabundant white-tailed deer in suburban landscapes. Wildlife Society Bulletin	Public Volunteer	<i>Odocoileus virginianus</i>





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Attachment 4: Strategic Alignment Report – First Person Consulting



Analysis Report

Supplementary Pest Control Trial Final Evaluation –
Alignment Review

Prepared for
Natural Resources Commission



RESEARCH



EVALUATION



DESIGN

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Executive Summary

Background

The Supplementary Pest Control Trial (SPC Trial) is run by the National Parks and Wildlife Service (NPWS), who have been partnering with volunteer shooters to help reduce pest animals in 12 national parks and reserves throughout New South Wales. This program has been running since early 2014 and is now coming to a close.

This alignment review forms part of the Final Evaluation of the SPC Trial, coordinated by the Natural Resources Commission and delivered by First Person Consulting. It builds on the Preliminary Evaluation (2014) and Interim Evaluation (2015), and is based on analysis of the following documents relevant to the SPC Trial:

- a sample of SPC Shoot Plans for six SPC Trial sites from 2015 and 2016
- Pest Management Site Plans (PMSP) for each SPC Trial site
- Regional Pest Management Strategies (RPMS) for all four regions in which SPC activities occur.

Key messages

- Shooting activities in SPC reserves are generally strategically aligned with other pest control activities done by NPWS and neighbours. PMSPs detail how SPC shooting activities are coordinated with other NPWS activities and describe wider involvement of neighbouring properties and community groups as well as coordination with other agencies in pest management activities.
- Relevant RPMSs identify priority species for a range of pest management control measures in each region, including the primary target species for the SPC Trial in each site. The SPC shooting activities in all sites generally target species ranked in the RPMSs as a “Critical” regional priority for management because of their impacts on threatened species. Key documents also indicate that shooting activities in SPC reserves are strategically aligned with other actions regarding SPC threatened species.
- The PMSPs for each region identify and document the highest priority pests for each SPC Trial site, referencing the priority pest species in the respective RPMS. PMSPs for all sites generally identify the same threatened species as identified in their respective RPMSs.
- Stated aims and objectives are generally aligned throughout the SPC Shoot Plans, PMSPs and RPMS according to the documentation reviewed, however there are some minor inconsistencies. Shoot Plans and PMSPs document how their objectives are informed by overarching plans and strategies including their RPMS.
- There is very little evidence that PMSPs have been updated since the Interim Evaluation in 2015. However, Shoot Plans for 2016 generally appear to complement the 2015 shooting operations, based on the sample of Shoot Plans we were provided with. This indicates a progression of strategic alignment between PMSPs and SPC Trial activities between 2015 and 2016.
- Table 1 outlines the findings of this review and the associated key evaluation question from the SPC trial Evaluation Framework.

Table 1. Relevant key evaluation questions, activities and findings for the SPC Trial as covered in this report.

Key Evaluation Questions	Sub-Questions	Relevant Activities	Findings
K2: How effective was the SPC trial?	KS4: To what extent has the SPC trial contributed to existing NPWS pest programs (incl. alignment and integration)?	A7: Review of strategic alignment of SPC activities	Shooting activities in SPC reserves are strategically aligned with other pest control activities done by NPWS
	KS6: To what extent have relevant native species populations been additionally protected?	A7: Review of strategic alignment of SPC activities	Shooting activities in SPC reserves are strategically aligned with other actions regarding SPC threatened species

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Acronyms

EEC	Endangered Ecological Community
LLS	Local Land Services
NP	National Park
NPWS	National Parks and Wildlife Service
NR	Nature Reserve
NRC	Natural Resources Commission
OEH	Office of Environment and Heritage
PMSP	Pest Management Site Plan
PoM	Plan of Management
RPMS	Regional Pest Management Strategy
SCA	State Conservation Area
Shoot Plans	Pest Management Shooting Operation Plans
SPC	Supplementary Pest Control program
TAP	Threat Abatement Plan

1 Introduction

1.1 Background

The Supplementary Pest Control Trial (SPC Trial) is run by the National Parks and Wildlife Service (NPWS), who have been partnering with volunteer shooters to help reduce pest animals in 12 national parks and reserves throughout New South Wales (Figure 1). This program has been running since early 2014 and is now coming to a close.

The Natural Resources Commission (NRC) is undertaking an evaluation of the SPC Trial.

As part of the evaluation, the NRC will consider:

- the effectiveness of the trial in contributing to the aims and objectives of existing NPWS pest control programs
- the efficiency of the trial
- the social impacts of the trial.

The NRC has developed an evaluation framework for guiding evaluation of the three-year trial. This includes three evaluation reports at different stages of the SPC trial:

- a Preliminary Evaluation report (December 2014)
- an Interim Evaluation report (November 2015)
- a Final Evaluation report (May 2017)(to which this document contributes).

First Person Consulting has compiled this report to assist NRC with preparation of the Final Evaluation report. It contributes to Activity 7 of the evaluation activities outlined in the SPC Trial Evaluation Implementation Plan.

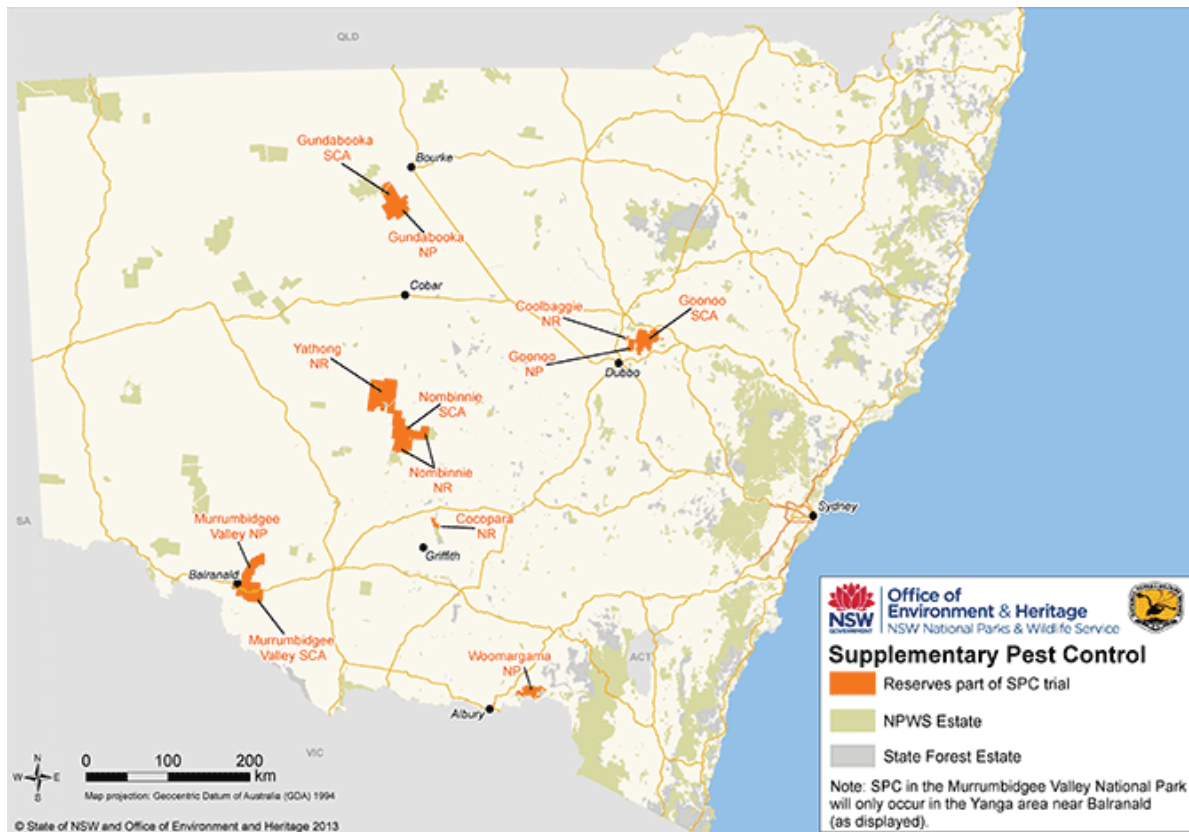


Figure 1. Map of the 12 SPC Trial sites (Source: <http://www.environment.nsw.gov.au/pestsweeds/spcParks.htm>)

1.2 Project scope

The scope of this report is to:

- Update the review of alignment between SPC activities and relevant legislation/policies under Activity 7 of the SPC Evaluation Implementation Plan, including a review of all six management sites.
- Review the alignment between a sample of Pest Management Shooting Operation Plans (Shoot Plans) and relevant policy and legislation.

Under this scope, this document reviews:

- Whether there has been strategic alignment of shooting activities in SPC reserves to contribute to other pest control activities by NPWS or neighbours.
- Whether there has been strategic alignment of shooting activities in SPC reserves to contribute to other actions regarding SPC threatened species.
- How the SPC trial identifies and documents the highest priority pests for each SPC reserve.
- Whether the aims and objectives identified within the pest management shooting operation plans and annual site plans logically align with each other, and with the five-year aims and objectives within the regional pest management strategies.
- Comparing pest management site plans and shooting operations plans for the six regions between 2015 and 2016, identifying what (if any) aspects of these plans have changed in the past year.

2 Methods

This report is based on a review of documents relevant to the SPC Trial, including:

- a sample of SPC Shoot Plans for six SPC Trial sites from 2015 and 2016
- Pest Management Site Plans (PMSP) for each SPC Trial site
- Regional Pest Management Strategies (RPMS) for all four regions in which SPC activities occur.

The documentation reviewed covers the 12 Reserves across six Management Sections in which SPC activities occur (Table 2) and the control of various pest animal species (Table 3).

Our strategic alignment analysis is limited by the documents that were provided to us. The PMSPs for each region are intended to be updated every year. We were advised that the PMSPs were updated in November 2015 and that dates were not updated, but some operational information was changed. However, of the PMSPs we were provided with, we can only see evidence that one of the PMSPs (for the Woomargama site) has been updated since the previous alignment review undertaken as part of the Interim Evaluation in 2015.

The review findings in this report have built upon the existing structure and content of two previous reports: the SPC Evaluation Preliminary Report by Roberts Evaluation in 2014 and the SPC Interim Evaluation Analysis Report on Activity 7 of the SPC Trial by First Person Consulting in 2015.

Table 2. SPC sites reserves and relevant regions. Note: NR = Nature Reserve, NP = National Park, SCA = State Conservation Area.

SPC Trial sites	Reserves within the site	Region
Central Mallee	Yathong NR, Nombinnie NR & SCA	Western Rivers
Cocopara	Cocopara NR	Western Rivers
Yanga	Murrumbidgee Valley NP & SCA	Western Rivers
Goonoo	Goonoo NP & SCA, Coolbaggie NR	Northern Plains
Gundabooka	Gundabooka NP & SCA	Far West
Woomargama	Woomargama NP	Southern Ranges

Table 3. Presence and priority of pest animal species in SPC Trial sites (as per relevant RPMS).

SPC Trial sites	Critical priority	Medium priority	Lower priority or other pests present
Central Mallee	Goats, foxes	Pigs, rabbits	Deer, wild dogs, feral cats, hare
Cocopara	Goats, rabbits		Pigs, deer, foxes, wild dogs, feral cats, hare
Yanga	Pigs, deer, rabbits	Foxes	Goats, wild dogs, feral cats, hare
Goonoo	Foxes		Rabbits, goats, pig, deer, wild dogs, feral cats, horses, hare
Gundabooka	Goats, pigs, wild dogs	Foxes	Deer, rabbits, feral cats, horses, hare
Woomargama	Goats, pigs, rabbits, foxes, wild dogs	Deer	Feral cats, horses, hare

3 Review of strategic alignment of SPC activities

3.1 Overview

Each of the points below relates directly to the elements in the Scope (Section 1.2) and summarises the reviewed material in Section 3 below.

Strategic alignment of shooting activities in SPC reserves to contribute to other pest control activities by NPWS or neighbours:

- Evidence from key documents indicates that shooting activities in SPC reserves are generally strategically aligned with other pest control activities done by NPWS and neighbours. Pest Management Site Plans (PMSPs) detail how SPC shooting activities are coordinated with other NPWS activities and describe wider involvement of neighbouring properties and community groups as well as coordination with other agencies in pest management activities (see Section 3.3.4 below).

Strategic alignment of shooting activities in SPC reserves to contribute to other actions regarding SPC threatened species:

- The relevant Regional Pest Management Strategies (RPMS) identify priority species for a range of pest management control measures in each region, including the primary target species for the SPC Trial in each site. The SPC shooting activities in all sites generally target species ranked in the RPMSs as a “Critical” regional priority for management because of their impacts on threatened species (Section 3.3.1). Key documents also indicate that shooting activities in SPC reserves are strategically aligned with other actions regarding SPC threatened species (see Section 3.3.3 below). Importantly, the RPMSs clearly note that the protection of these threatened species requires the effective control of the priority pest species for each site.

How the SPC trial identifies and documents the highest priority pests for each SPC reserve:

- The PMSPs for each region identify and document the highest priority pests for each SPC Trial site, referencing the priority pest species in the respective RPMS. PMSPs for all sites generally identify the same threatened species as identified in their respective RPMSs (Section 3.3.5).

Alignment between aims and objectives identified within the RPMS, PMSP and Shoot Plans relevant to each site:

- Aims and objectives are generally aligned throughout the SPC Shoot Plans, PMSPs and RPMS according to the documentation reviewed, however there are some instances of misalignment. Shoot Plans and PMSPs document how their objectives are informed by overarching plans and strategies including their RPMS. (Section 3.3.5).

Progression of strategic alignment between PMSPs and SPC Trial activities between 2015 and 2016:

- There is very little evidence that PMSPs have been updated since the 2015 Interim Evaluation with any substantial new information relating to planned pest control operations or relevant strategic information.
- Shoot Plans for 2016 SPC Trial operations generally appear to complement the 2015 shooting operations, based on the sample of Shoot Plans we were provided with.

3.2 Key vertebrate pest species

There are a range of vertebrate pest species across the regions examined here. Within the SPC trial sites, a subset of these pests are of priority importance and, as such, are the target species of the SPC Trial.

The pest species identified in Table 3 (above) have both direct and indirect impacts within these regions, including:

- Impacts on native vegetation through selective browsing. Goats, rabbits and deer can have significant impacts on native vegetation communities through grazing/over-grazing of key species. This can lead to changes in species composition and vegetation structure.¹ Rabbits can also prevent the regeneration of grazed species through the consumption of seeds and seedlings. Digging by rabbits can also damage root systems.²
- Impacts on vegetation through trampling by horses, goats, pigs and deer. This leads to the degradation of native vegetation and the loss of plant cover, accelerating soil erosion as a result.³
- Erosion and water quality impacts on waterways, for example soil disturbance and fouling caused by feral pigs.⁴
- Impacts on cultural heritage sites, such as rabbits burrowing within Indigenous burial sites.⁵
- Flow-on impacts on the capacity of native fauna to access food and shelter.⁶
- Predation by foxes, pigs and feral cats and dogs also threaten native species, such as ringtail, brush-tail and eastern pygmy possums, koalas, swamp wallabies, plains-wanderers, bush stone-curlew, malleefowl and other ground-nesting birds such as superb lyrebirds and powerful owls.⁷

¹ Office of Environment and Heritage, 2012, *Regional Pest Management Strategy 2012-2017: Western Rivers Region*.

² *Ibid.*

³ Office of Environment and Heritage, 2012, *Regional Pest Management Strategy 2012-2017: Western Rivers Region*.

⁴ Office of Environment and Heritage, 2012, *Regional Pest Management Strategy 2012-2017: Far West Region*.

⁵ Office of Environment and Heritage, 2012, *Regional Pest Management Strategy 2012-2017: Western Rivers Region*.

⁶ *Ibid.*

⁷ Office of Environment and Heritage, 2012, *Regional Pest Management Strategy 2012-2017: Southern Ranges Region*; Office of Environment and Heritage, 2012, *Regional Pest Management Strategy 2012-2017: Western Rivers Region*.

- Impacts on properties neighbouring parks, through the effects of soil erosion on crop yields, fouling of water sources, competition with livestock for feed, trampling of fences and preying upon young livestock.⁸

3.3 Review findings

3.3.1 Alignment of key target vertebrate pest species

Priority or target pest species are listed in the PMSP and Shoot Plans for each site and site specific priority species are also identified in each RPMS. Table 5 to Table 10 below details the primary and secondary target species identified in Regional Pest Management Strategies, Pest Management Site Plans and SPC Shoot Plans for each site.

The documents reviewed indicate that the pest species being targeted through SPC shoots are generally well aligned with pest management priorities for the sites.

- All sites generally list priority species in their PMSPs that are consistent with regional priorities in the relevant RPMS.
- SPC Shoot Plans generally identify primary target species that are aligned with the relevant RPMS and PMSP for that site (Table 5 to Table 10).

However, there are some exceptions:

- Shoot Plans identify primary target species that are sometimes not listed as regional priorities in the relevant RPMS or not listed as a primary target species in the relevant PMSP. There are instances where one or more of the primary target species for the SPC Trial listed in the PMSP were only targeted as a secondary species in the 2015 and 2016 Shoot Plans provided for analysis (Table 4).
- There are some instances where species listed as a critical priority for a site in the relevant RPMS are not listed as primary target species in the corresponding PMSP (rabbits in Cocopara, and foxes and wild dogs in Woomargama) (Table 4).
- There may be species specific or site specific reasons, such as changing population numbers or changes in habitat conditions, since the regional strategies and site plans were developed which may explain these inconsistencies.

Table 4. Inconsistencies between RPMS, PMSP and Shoot Plans for each SPC Trial site.

SPC Trial site	Inconsistencies between RPMS, PMSP and Shoot Plans
Central Mallee	In the Central Mallee PMSP, goats and foxes are listed as the primary target species for the SPC. The 2015 and 2016 SPC shoot plans list foxes as the primary target for all shoots, but they also list feral cats as a primary target for three operations in 2016 despite not being listed as a regional priority in

⁸ Office of Environment and Heritage, 2012, *Regional Pest Management Strategy 2012-2017: Northern Plains Region*.

	the Western Rivers RPMS or a primary target species in the PMSP (Table 5). Goats were only every secondary targets in shoot plans.
Cocopara	Goats and pigs are listed as the primary target species for the SPC Trial in the PMSP for the Cocopara region. This is reflected in the shoot plans, with pigs as the primary target in the March 2015 and June 2016 operations and goats as the primary target in the September 2016 operation. However, pigs are not listed as a management priority for the Cocopara site in the Western Rivers RPMS. Rabbits are listed as a critical priority for Cocopara in the RPMS, however this is not reflected in the PMSP (Table 6).
Gundabooka	Of the primary target species for the Gundabooka site (goats, pigs, foxes and wild dogs), it is unclear from the PMSP which species were intended to be targeted through the SPC Trial. Goats were identified as the primary target species in all six shoot plans available from 2015 and 2016, with pigs, foxes and wild dogs listed as secondary targets (Table 9).
Woomargama	<p>Of the primary target species for the Woomargama region (goats, pigs and rabbits), it is unclear from the PMSP which species were intended to be targeted through the SPC Trial. Rabbits were listed as the primary target species for the May 2015 operation and pigs were listed as the primary target for the four SPC shooting operations in 2016.</p> <p>Foxes and wild dogs were listed as critical priority pests for the Woomargama site in the Southern Ranges RPMS, however they dogs are not identified as primary target species in the PMSP or Shoot Plans (Table 10).</p>

Table 5. Priority pest species in the Western Rivers Region of NSW and target pests for the Central Mallee SPC trial.

Common name	Scientific name	Pest in Western Rivers Region ⁹	Priority pests for Central Mallee (as per RPMs) ¹⁰	Central Mallee PMSP ¹¹		Central Mallee shoot plans				
				Primary target species	Y	Primary SPC target species	Y	March 2016 ¹³	June 2016 ¹⁴	October 2016 ¹⁵
Goats	Capra hircus	Y	Critical priority	Y	Y	Secondary	Secondary	Secondary	Secondary	Secondary
Pigs	Sus scrofa	Y	Medium priority			Secondary	Secondary	Secondary	Secondary	Secondary
Deer	Family cervidae	Y				Secondary	Secondary	Secondary	Secondary	Secondary
Rabbits	Oryctolagus cuniculus	Y	Medium priority	Y		Secondary	Secondary	Secondary	Secondary	Secondary
Foxes	Vulpes vulpes	Y	Critical priority	Y	Y	Primary	Primary	Primary	Primary	Primary
Wild dogs	Canis lupus familiaris	Y				Secondary	Secondary	Secondary	Secondary	Secondary
Feral cats	Felis catus	Y				Secondary	Primary	Secondary	Primary	Primary
Horses	Equus caballus									
Hare	Lepus europaeus					Secondary	Secondary	Secondary	Secondary	Secondary

⁹ Office of Environment and Heritage, 2012, Regional Pest Management Strategy 2012-2017: Western Rivers Region.

¹⁰ Ibid.

¹¹ NSW National Parks and Wildlife Service, 2015, Central Mallee Pest Management Site Plan.

¹² Office of Environment and Heritage, 2015, Central Mallee SPC Shooting Operations Plan 28-04-2015 to 30-04-2015.

¹³ Office of Environment and Heritage, 2016, Central Mallee SPC Shooting Operations Plan 30-03-2016 to 01-04-2016.

¹⁴ Office of Environment and Heritage, 2016, Central Mallee SPC Shooting Operations Plan 21-06-2016 to 22-06-2016.

¹⁵ Office of Environment and Heritage, 2016, Central Mallee SPC Shooting Operations Plan 11-10-2016 to 13-10-2016.

¹⁶ Office of Environment and Heritage, 2016, Central Mallee SPC Shooting Operations Plan 15-11-2016 to 17-11-2016.

Table 6. Priority pest species in the Western Rivers Region of NSW and target pests for the Cocopara NR SPC trial.

Common name	Scientific name	Pest in Western Rivers Region ¹⁷	Priority pests for Cocopara (as per RPMS) ¹⁸	Cocopara (PMSP) ¹⁹		Cocopara shoot plans		
				Primary target species	Primary SPC target species	March 2015 ²⁰	June 2016 ²¹	September 2016 ²²
Goats	Capra hircus	Y	Critical priority	Y	Y	Secondary	Secondary	Primary
Pigs	Sus scrofa	Y		Y	Y	Primary	Primary	Secondary
Deer	Family cervidae	Y				Secondary	Secondary	Secondary
Rabbits	Oryctolagus cuniculus	Y	Critical priority			Secondary	Secondary	Secondary
Foxes	Vulpes vulpes	Y				Secondary	Secondary	Secondary
Wild dogs	Canis lupus familiaris	Y				Secondary	Secondary	Secondary
Feral cats	Felis catus	Y				Secondary	Secondary	Secondary
Horses	Equus caballus							
Hare	Lepus europaeus					Secondary	Secondary	Secondary

¹⁷ Office of Environment and Heritage, 2012, Regional Pest Management Strategy 2012-2017: Western Rivers Region.

¹⁸ Ibid.

¹⁹ NSW National Parks and Wildlife Service, 2015, Cocopara Pest Management Site Plan.

²⁰ Office of Environment and Heritage, 2015, Cocopara SPC Shooting Operations Plan 07-03-2015 to 07-03-2015.

²¹ Office of Environment and Heritage, 2015, Cocopara SPC Shooting Operations Plan 02-06-2016 to 03-06-2016.

²² Office of Environment and Heritage, 2015, Cocopara SPC Shooting Operations Plan 20-09-2016 to 23-09-2016.

Table 7. Priority pest species in the Western Rivers Region of NSW and target pests for the Yanga SPC trial.

Common name	Scientific name	Pest in Western Rivers Region ²³	Priority pests for Yanga (as per RPMs) ²⁴	Primary target species	Primary SPC target species	July 2015 ²⁶	February 2016 ²⁷	August 2016 ²⁸	December 2016 ²⁹
Goats	Capra hircus	Y				Secondary	Secondary	Secondary	Secondary
Pigs	Sus scrofa	Y	Critical priority	Y	Y	Primary	Secondary	Secondary	Secondary
Deer	Family cervidae	Y	Critical priority	Y	Y	Secondary	Secondary	Secondary	Secondary
Rabbits	Oryctolagus cuniculus	Y	Critical priority	Y	Y	Secondary	Primary	Primary	Primary
Foxes	Vulpes vulpes	Y	Medium priority			Secondary	Secondary	Secondary	Secondary
Wild dogs	Canis lupus familiaris	Y				Secondary	Secondary	Secondary	Secondary
Feral cats	Felis catus	Y				Secondary	Secondary	Secondary	Secondary
Horses	Equus caballus								
Hare	Lepus europaeus					Secondary	Secondary	Secondary	Secondary

²³ Office of Environment and Heritage, 2012, Regional Pest Management Strategy 2012-2017: Western Rivers Region.

²⁴ Ibid.

²⁵ NSW National Parks and Wildlife Service, 2015, Yanga Pest Management Site Plan.

²⁶ Office of Environment and Heritage, 2015, Yanga SPC Shooting Operations Plan 15-07-2015 to 17-07-2015.

²⁷ Office of Environment and Heritage, 2016, Yanga SPC Shooting Operations Plan 29-02-2016 to 04-03-2016.

²⁸ Office of Environment and Heritage, 2016, Yanga SPC Shooting Operations Plan 16-08-2016 to 19-08-2016.

²⁹ Office of Environment and Heritage, 2016, Yanga SPC Shooting Operations Plan 13-12-2016 to 15-12-2016.

Table 8. Priority pest species in the Northern Plains Region of NSW and target pests for the Goonoo SPC trial.

Common name	Scientific name	Pest in Northern Plains Region ³⁰	Priority pests for Goonoo (as per RPMS) ³¹	Goonoo (PMSP) ³²		Goonoo shoot plans				
				Primary target species	Primary SPC target species	April 2015 ³³	March 2016 ³⁴	July 2016 ³⁵	August 2016 ³⁶	November 2016 ³⁷
Goats	Capra hircus	Y	Y	Y		Secondary	Secondary	Secondary	Secondary	Secondary
Pigs	Sus scrofa	Y				Secondary	Secondary	Secondary	Secondary	Secondary
Deer	Family cervidae	Y				Secondary	Secondary	Secondary	Secondary	Secondary
Rabbits	Oryctolagus cuniculus	Y	Lower priority			Secondary	Secondary	Secondary	Secondary	Secondary
Foxes	Vulpes vulpes	Y	Critical priority	Y	Y	Primary	Primary	Primary	Primary	Primary
Wild dogs	Canis lupus familiaris	Y				Secondary	Secondary	Secondary	Secondary	Secondary
Feral cats	Felis catus	Y				Secondary	Secondary	Secondary	Secondary	Secondary
Horses	Equus caballus	Y								
Hare	Lepus europaeus					Secondary	Secondary	Secondary	Secondary	Secondary

³⁰ Office of Environment and Heritage, 2012, Regional Pest Management Strategy 2012-2017: Northern Plains Region.

³¹ Ibid.

³² NSW National Parks and Wildlife Service, 2015, Goonoo Pest Management Site Plan.

³³ Office of Environment and Heritage, 2015, Goonoo SPC Shooting Operations Plan 29-04-2015 to 01-05-2015.

³⁴ Office of Environment and Heritage, 2016, Goonoo SPC Shooting Operations Plan 07-03-2016 to 11-03-2016.

³⁵ Office of Environment and Heritage, 2016, Goonoo SPC Shooting Operations Plan 18-07-2016 to 23-07-2016.

³⁶ Office of Environment and Heritage, 2016, Goonoo SPC Shooting Operations Plan 29-08-2016 to 03-09-2016.

³⁷ Office of Environment and Heritage, 2016, Goonoo SPC Shooting Operations Plan 28-11-2016 to 02-12-2016.

Table 9. Priority pest species in the Far West Region of NSW and target pests for the Gundabooka SPC trial.

Common name	Scientific name	Pests in Far West Region ³⁸	Priority pests Gundabooka (per RPMS) ³⁹	Gundabooka (PMSP) ⁴⁰		Gundabooka shoot plans					
				Primary target species	Primary SPC target species	July 2015 ⁴¹	February 2016 ⁴²	April 2016 ⁴³	May 2016 ⁴⁴	October 2016 ⁴⁵	November 2016 ⁴⁶
Goats	<i>Capra hircus</i>	Y	Critical priority	Y	Unclear	Primary	Primary	Primary	Primary	Primary	Primary
Pigs	<i>Sus scrofa</i>	Y	Critical priority	Y		Secondary	Secondary	Secondary	Secondary	Secondary	Secondary
Deer	Family cervidae	Y				Secondary	Secondary	Secondary	Secondary	Secondary	Secondary
Rabbits	<i>Oryctolagus cuniculus</i>	Y				Secondary	Secondary	Secondary	Secondary	Secondary	Secondary
Foxes	<i>Vulpes vulpes</i>	Y	Medium priority	Y		Secondary	Secondary	Secondary	Secondary	Secondary	Secondary
Wild dogs	<i>Canis lupus familiaris</i>	Y	Critical priority	Y		Secondary	Secondary	Secondary	Secondary	Secondary	Secondary
Feral cats	<i>Felis catus</i>	Y				Secondary	Secondary	Secondary	Secondary	Secondary	Secondary
Horses	<i>Equus caballus</i>	Y									
Hare	<i>Lepus europaeus</i>					Secondary	Secondary	Secondary	Secondary	Secondary	Secondary

³⁸ Office of Environment and Heritage, 2012, Regional Pest Management Strategy 2012-2017: Far West Region.³⁹ Ibid.⁴⁰ NSW National Parks and Wildlife Service, 2015, Gundabooka Pest Management Site Plan.⁴¹ Office of Environment and Heritage, 2015, Gundabooka SPC Shooting Operations Plan 26-07-2015 to 29-07-2015.⁴² Office of Environment and Heritage, 2016, Gundabooka SPC Shooting Operations Plan 09-02-2016 to 11-02-2016.⁴³ Office of Environment and Heritage, 2016, Gundabooka SPC Shooting Operations Plan 05-04-2016 to 06-04-2016.⁴⁴ Office of Environment and Heritage, 2016, Gundabooka SPC Shooting Operations Plan 17-05-2016 to 20-05-2016.⁴⁵ Office of Environment and Heritage, 2016, Gundabooka SPC Shooting Operations Plan 17-10-2016 to 21-10-2016.⁴⁶ Office of Environment and Heritage, 2016, Gundabooka SPC Shooting Operations Plan 07-11-2016 to 11-11-2016.

Table 10. Priority pest species in the Southern Ranges Region of NSW and target pests for the Woomargama SPC trial.

Common name	Scientific name	Pest in Southern Ranges Region ⁴⁷	Priority pest for Woomargama (RPMS) ⁴⁸	Primary target species	Woomargama PMSP ⁴⁹ Primary target species	May 2015 ⁵⁰	May 2016 ⁵¹	August 2016 ⁵²	November 2016 (early) ⁵³	November 2016 (late) ⁵⁴
Goats	<i>Capra hircus</i>	Y	Critical priority	Y	Unclear	Secondary	Secondary	Secondary	Secondary	Secondary
Pigs	<i>Sus scrofa</i>	Y	Critical priority	Y		Secondary	Primary	Primary	Primary	Primary
Deer	Family cervidae	Y	Medium priority			Secondary	Secondary	Secondary	Secondary	Secondary
Rabbits	<i>Oryctolagus cuniculus</i>	Y	Critical priority	Y		Primary	Secondary	Secondary	Secondary	Secondary
Foxes	<i>Vulpes vulpes</i>	Y	Critical priority (NP & SCA)			Secondary	Secondary	Secondary	Secondary	Secondary
Wild dogs	<i>Canis lupus familiaris</i>	Y	Critical priority (NP & SCA)			Secondary	Secondary	Secondary	Secondary	Secondary
Feral cats	<i>Felis catus</i>	Y				Secondary	Secondary	Secondary	Secondary	Secondary
Horses	<i>Equus caballus</i>	Y								
Hare	<i>Lepus europaeus</i>	Y				Secondary		Secondary	Secondary	Secondary

⁴⁷ Office of Environment and Heritage, 2012, Regional Pest Management Strategy 2012-2017: Southern Ranges Region.

⁴⁸ Ibid.

⁴⁹ NSW National Parks and Wildlife Service, 2015, Woomargama National Park Pest Management Site Plan.

⁵⁰ Office of Environment and Heritage, 2015, Woomargama SPC Shooting Operations Plan 07-05-2015 to 08-05-2015.

⁵¹ Office of Environment and Heritage, 2016, Woomargama SPC Shooting Operations Plan 12-05-2016 to 13-05-2016.

⁵² Office of Environment and Heritage, 2016, Woomargama SPC Shooting Operations Plan 20-08-2016 to 23-08-2016.

⁵³ Office of Environment and Heritage, 2016, Woomargama SPC Shooting Operations Plan 08-11-2016 to 10-11-2016.

⁵⁴ Office of Environment and Heritage, 2016, Woomargama SPC Shooting Operations Plan 26-11-2016 to 27-11-2016.

3.3.2 Management strategies

The NPWS uses an array of management techniques to address pest species and their impacts, including.⁵⁵

- Ground shooting
- Aerial shooting
- Trapping (including passive trapping)
- Baiting
- Mustering
- Exclusion fencing
- Fumigation
- Warren ripping.

Ground shooting, such as that used in the SPC trial, is one of a range of techniques used by the NPWS. Table 11 details the range of pest control techniques used in the SPC trial sites for the target species, the role of SPC trial program in the site's management strategy, and alignment of the technique with recommended management practice for that species in NSW and Australia.

Broadly, the multi-technique approach taken by NPWS is a widely supported strategy for pest management. The OEH notes that "pest animal management works best as part of an integrated program using a variety of techniques, because individual animals that are not susceptible to one technique can be removed using another."⁵⁶ For example, shooting activities may be beneficial for goats that are trap shy or in heavily forested areas where aerial shooting activities are limited.⁵⁷

The Invasive Animals Cooperative Research Centre emphasises that ground shooting "should only be used in a strategic manner as part of a coordinated program."⁵⁸ For example, ground shooting is most effective as "a follow-up after initial reduction of goat numbers by mustering or aerial shooting", particularly in controlling small, isolated groups or when other techniques cannot be used.⁵⁹ However, ground shooting is a time consuming and labour intensive process and is "not considered an effective method for large-scale control", particularly when dealing with large and/or dispersed feral animal populations.⁶⁰ Other methods, such as aerial shooting or baiting, are more suitable in such cases.

Evidence from phone surveys conducted with park neighbours through the SPC Final Evaluation, suggests that the SPC is only supported by some landholders to the extent that it complements

⁵⁵ NSW National Parks and Wildlife Service, 2013, <<http://www.environment.nsw.gov.au/pestsweeds/spcSupporting.htm>>.

⁵⁶ The Office of Environment and Heritage, 2013, 'Supporting NPWS Pest Management', <<http://www.environment.nsw.gov.au/pestsweeds/spcSupporting.htm>>.

⁵⁷ Queensland Department of Agriculture, Fisheries and Forestry, 2010, *Feral Goat Fact Sheet*, p. 3, <http://www.daff.qld.gov.au/__data/assets/pdf_file/0012/55200/IPA-Feral-Goat-PA18.pdf>.

⁵⁸ Sharp, T, 2012, *Ground Shooting of Feral Goats*, <http://www.feral.org.au/wp-content/uploads/2012/12/GOA001_ground-shooting_web.pdf>.

⁵⁹ *Ibid.*

⁶⁰ *Ibid.*; Pestsmart Connect, Invasive Species CRC, Aerial and Ground Shooting for Feral Pig Control. Available at <http://www.pestsmart.org.au/shooting-for-feral-pig-control/>, accessed on 04/09/2015;

other pest control methods. For example, when asked to what extent they support ground shooting in NSW parks and reserves, various landholders responded:

*“As long as aerial shooting and baiting is still done, [they] need to use every avenue.”
(landholder phone survey, Yathong Nature Reserve neighbour)*

“I feel ground shooting coupled with baiting programs gives the best results.” (landholder phone survey, Cocopara Nature Reserve neighbour)

“[Ground shooting] can be a useful component of an integrated pest management strategy. On its own it’s not effective and if it’s not well managed it probably does more harm than good.” (landholder phone survey, Yanga Complex neighbour)

“I think you need a bit of everything to make pest control really work.” (landholder phone survey, Round Hill Nature Reserve neighbour)

3.3.3 Appropriateness of management strategies

The appropriateness and effectiveness of ground shooting as a control strategy differs for each target species and depends on other control activities being undertaken. The appropriateness of SPC ground shooting as a technique for each species is based on the information provided in the Shoot Plans and PMSPs for each site. It is important to note that the evaluation of the appropriateness of the techniques is limited to the information provided in the documentation, not how those techniques were actually applied in practice.

Based on the information provided in the documents, the use of ground shooting appears well suited to most species targeted in the SPC shooting activities:

- SPC shooting activities for most sites are scheduled to take place following the implementation of other control techniques such as baiting or aerial shooting, enhancing the effectiveness of ground shooting as a measure to suppress population re-establishment.
- PMSPs typically describe the use of SPC shooting activities to directly support or complement other pest management activities. For example, Cocopara PMSP states: “Ground shooting by volunteers will target pigs and residual goat populations not removed through scheduled programs (strategic or reactive)... These operations will also encourage the movement of goats off park onto a neighbouring property through one-way gates.”⁶¹ The use of SPC shooting as a complementary measure enhances its effectiveness and value as a control strategy.
- The value of the SPC ground shooting activities is enhanced by each shoot being carried out to effectively target only one or two species, ensuring that timing, location and conditions are suitable. Most plans also describe flexible arrangements for when the SPC shoots are scheduled to ensure they complement other planned activities and conditions.

⁶¹ Cocopara NR SPC 07-03-15 to 08-03-15 *Shooting Operations Plan*.

There were some instances where the use of ground shooting for the species targeted is generally not considered an effective technique (Table 11). However, two of the three cases appeared to be justified on the basis that the ground shooting complemented other techniques or is useful at low pest numbers:

- Foxes are listed as a primary target of SPC shooting activities in the PMSP for Central Mallee and Goonoo. Ground shooting is generally considered an ineffective and labour intensive control strategy for foxes, except as a viable secondary option where baiting is ineffective or inappropriate⁶². In this case, it appears to complement the extensive baiting program in the Central Mallee region.
- The Woomargama PSMP lists rabbits as an opportunistic target, however they were the primary target of the shoot conducted in May 2015. Ground shooting of rabbits is labour intensive and typically considered effective only at low population levels. This appears to be the case in Woomargama, where the Shoot Plan notes the SPC operation will “assist in keeping pest densities at low levels”.⁶³
- Feral cats are listed as one of the primary targets of the SPC Trial for the March, October and November 2016 shooting operations in Central Mallee. Cats are a difficult pest to shoot and ground shooting is generally an ineffective method of substantially reducing feral cat populations.⁶⁴ It is recommended that ground shooting of feral cats should be conducted to supplement other control methods, however the Central Mallee PMSP does not include any pest management techniques that primarily target feral cats. It is unclear what control methods the SPC Trial is complementing through its focus on ground shooting of feral cats in these shooting operations.

A summary of advice on the value of ground shooting as a control technique according to current best practice for each species targeted through the SPC Trial is provided below in Table 11. Similar information was provided through the 2015 Interim Evaluation and a review of any new or updated relevant literature was undertaken. Aside from the addition of best practice recommendations for controlling feral cats through ground shooting, it was determined that this information still currently represents best practice and has not be updated.

Table 12 details the role of SPC ground shooting within the PMSP for each site and the alignment of ground shooting with control techniques for each species. This was also provided through the 2015 Interim Evaluation, and has since been updated with additional evidence from 2015 and 2016 Shoot Plans where relevant.

⁶² Pestsmart Connect, Invasive Species CRC, Fox Shooting and Hunting. Available at <http://www.pestsmart.org.au/fox-shooting-and-hunting/>, accessed on 04/09/2015.

⁶³ Office of Environment and Heritage, 2015, *Woomargama SPC Shooting Operations Plan 07-05-2015 to 08-05-2015*, p. 3.

⁶⁴ Pestsmart Connect, Invasive Species CRC, Ground Shooting of Feral Cats. Available at http://www.pestsmart.org.au/wp-content/uploads/2013/01/CAT001_ground-shooting_web.pdf, accessed on 31/10/2016.

Table 11. Summary of recommended practice in use of ground shooting as management strategy by target species

Species	Recommended ground shooting practice
Rabbits	<p>“Shooting may be useful when rabbit numbers are already low, but it is labour intensive and is not effective as a general rabbit control method. Shooting is usually done at night with the aid of a spotlight, but can also be conducted during the day.”⁶⁵</p>
Pigs	<p>“Ground shooting is not effective in reducing the pig population unless intense shooting is undertaken on a small isolated and accessible population of pigs.”⁶⁶</p> <p>“Ground shooting using large calibre, high-powered rifles can be a useful technique for controlling small, isolated feral pig populations or where other techniques cannot be used. It is often used as a secondary control method, or during ‘mop up’ operations after the initial reduction of high density pig populations by aerial shooting or baiting. Ground shooting should not occur prior to, or during trapping and poison baiting programs because it is ‘intrusive’ and can disrupt pig activity, causing pigs to move to other areas. Ground shooting is not suitable for population-scale management across large areas, particularly when the pig density is low. Intensive ground shooting — both recreational and professional — can be effective in some localised settings where pig numbers are low. Due to high labour and time costs, and the localised nature of this form of control, ground shooting [is] more suited to short-term management campaigns. Ground shooting... should be used as a secondary method to other more productive forms of control.”⁶⁷</p>
Goats	<p>“Ground shooting is labour intensive but can produce good results if control programs are well planned and the effort is maintained.”⁶⁸</p> <p>“It is best suited to accessible areas with high feral goat populations.”⁶⁹</p> <p>“Shooting feral goats from the ground is most successful in the more open pastoral areas, especially when goats are forced to visit water points. However, too much harassment can prompt some goats to find alternative water sites or to</p>

⁶⁵ Pestsmart Connect, Invasive Species CRC, Ground Shooting of Rabbits. Available at <http://www.pestsmart.org.au/ground-shooting-of-rabbits/>, accessed on 04/09/2015.

⁶⁶ Department of Agriculture and Fisheries, Feral Pig Control. Available at <https://www.daf.qld.gov.au/plants/weeds-pest-animals-ants/pest-animals/control-methods/feral-pig-control>, accessed on 04/09/2015.

⁶⁷ Pestsmart Connect, Invasive Species CRC, Practical Feral Pig Control. Available at <http://www.pestsmart.org.au/pestsmart-factsheet-practical-feral-pig-control/http://www.pestsmart.org.au/ground-shooting-of-feral-goats/>, accessed on 04/09/2015.

⁶⁸ Department of Agriculture and Fisheries, Feral Goat. Available at <https://www.daf.qld.gov.au/plants/weeds-pest-animals-ants/pest-animals/a-z-listing-of-pest-animals/photo-guide-to-pest-animals/feral-goat>, accessed on 04/09/2015.

⁶⁹ Pestsmart Connect, Invasive Species CRC, Ground Shooting of Feral Goats. Available at <http://www.pestsmart.org.au/ground-shooting-of-feral-goats/>, accessed on 04/09/2015.

	drink at night. Ground-based shooting can be useful when targeting particular goats." ⁷⁰
Deer	<p>"Although time consuming and labour intensive, ground shooting is considered to be the most effective and humane technique currently available for reducing wild deer populations. Such shooting is usually done at night from a vehicle, with the aid of spotlights."⁷¹</p> <p>"It is best suited to accessible areas where large numbers of deer congregate at night and where the impact of deer is greatest."⁷²</p>
Foxes	"Shooting is considered an ineffective way of significantly reducing fox numbers, so is often used in combination with other methods. It is labour intensive and not as cost efficient as poison (1080) baiting on a broad scale. Shooting is a very selective method of fox control. It can provide a viable alternative in areas where foxes are bait shy, where 1080 baiting is not feasible, or where baiting is not a preferred option." ⁷³
Wild dogs	"It is labour intensive and considered an ineffective technique to reduce populations of wild dogs over extensive areas. Shooting is usually done during the day but can also be conducted at night with the aid of a spotlight. Organised wild dog drives using a line of beaters to flush dogs into a line of guns are sometimes used." ⁷⁴
Feral cats	<p>"Although shooting can result in a localised reduction in feral cat numbers, it is ineffective in significantly reducing feral cat populations, particularly over the longer-term. Feral cats generally avoid human contact making them difficult to shoot."⁷⁵</p> <p>"Shooting is more successful in areas with flat topography and open vegetation. It is not suitable where dense cover exists or in the vicinity of human habitation."⁷⁶</p>

⁷⁰ NSW Department of Primary Industries, Feral Goat Control. Available at <http://www.dpi.nsw.gov.au/agriculture/pests-weeds/vertebrate-pests/pest-animals-in-nsw/feral-goat-control><http://www.dpi.nsw.gov.au/agriculture/pests-weeds/vertebrate-pests/pest-animals-in-nsw/feral-pig-control>, accessed on 04/09/2015.

⁷¹ Department of Agriculture and Fisheries, Feral Fallow Deer Factsheet. Available at https://www.daf.qld.gov.au/_data/assets/pdf_file/0005/69719/IPA-Fallow-Deer-Factsheet.pdf, accessed on 04/09/2015.

⁷² Pestsmart Connect, Invasive Species CRC, Ground Shooting of Feral Deer. Available at <http://www.pestsmart.org.au/ground-shooting-of-wild-deer/>, accessed on 04/09/2015.

⁷³ Pestsmart Connect, Invasive Species CRC, Fox Shooting and Hunting. Available at <http://www.pestsmart.org.au/fox-shooting-and-hunting/>, accessed on 04/09/2015.

⁷⁴ Pestsmart Connect, Invasive Species CRC, Ground Shooting of Wild Dogs. Available at <http://www.pestsmart.org.au/ground-shooting-of-wild-dogs/>, accessed on 04/09/2015.

⁷⁵ Pestsmart Connect, Invasive Species CRC, Ground Shooting of Feral Cats. Available at http://www.pestsmart.org.au/wp-content/uploads/2013/01/CAT001_ground-shooting_web.pdf, accessed on 31/10/2016.

⁷⁶ Pestsmart Connect, Invasive Species CRC, Ground Shooting of Feral Cats. Available at http://www.pestsmart.org.au/wp-content/uploads/2013/01/CAT001_ground-shooting_web.pdf, accessed on 31/10/2016.

Table 12. Alignment of ground shooting with recommended control techniques for each species

SPC Trial site	Target species (as per PMSP)	Management objective (from PSMP and SPC Shoot Plans)	Control techniques (from PMSP and SPC Shoot Plans)	Role of SPC program (from PMSP)	Alignment with recommended use of ground shooting as control strategy	Example evidence (Shoot Plans)
Cocopara	Goats	Reduce numbers	FAAST program Trapping (passive) SPC (primary target)	Target residual populations not removed through scheduled programs, as well as population suppression throughout year. Complement passive goat trapping program through encouraging movement off park through one-way gates.	<ul style="list-style-type: none"> ✓ Most effective when used as follow-up to other control strategies⁷⁷ ✓ Best suited to areas with high goat population⁷⁸ ✓ Most effective in open landscapes (e.g. woodlands)⁷⁹ 	“This ground shooting operation is focused on the removal of goats which have not been trapped or removed during other pest programs in this reserve. This planned program also allows for the other pest species to be removed if sighted during this operation.” ⁸⁰
	Pigs	Maintain current low densities	FAAST program Baiting/trapping SPC (primary target)		<ul style="list-style-type: none"> ✓ Useful as a complementary method to other forms of control⁸¹ ✓ Effective for maintaining low numbers ✓ Timed with other control activities to avoid disruption and dispersal to other areas⁸² 	“This SPC operation is following a strategic NPWS feral pig baiting program, concentrating on feral pigs throughout the Cocopara NR landscape. The strategic control program, undertaken by Mid West Area staff will complement the Riverina LLS staffs’ activities, to control

⁷⁷ Pestsmart Connect, Invasive Species CRC, Ground Shooting of Feral Goats. Available at <http://www.pestsmart.org.au/ground-shooting-of-feral-goats/>, accessed on 04/09/2015.

⁷⁸ *Ibid.*

⁷⁹ NSW Department of Primary Industries, Feral Goat Control. Available at <http://www.dpi.nsw.gov.au/agriculture/pests-weeds/vertebrate-pests/pest-animals-in-nsw/feral-goat-control/http://www.dpi.nsw.gov.au/agriculture/pests-weeds/vertebrate-pests/pest-animals-in-nsw/feral-pig-control>, accessed on 04/09/2015

⁸⁰ Office of Environment and Heritage, 2015, Cocopara SPC Shooting Operations Plan 20-09-2016 to 23-09-2016.

⁸¹ Pestsmart Connect, Invasive Species CRC, Practical Feral Pig Control. Available at [http://www.pestsmart.org.au/ground-shooting-of-feral-goats/](http://www.pestsmart.org.au/pestsmart-factsheet-practical-feral-pig-control/http://www.pestsmart.org.au/ground-shooting-of-feral-goats/), accessed on 04/09/2015.

⁸² NSW Department of Primary Industries, Feral Pig Control. Available at <http://www.dpi.nsw.gov.au/agriculture/pests-weeds/vertebrate-pests/pest-animals-in-nsw/feral-pig-control>, accessed on 04/09/2015

Central Mallee	Foxes	Reduce and suppress numbers ⁸⁴	Aerial transect 1080 baiting Ground 1080 baiting/M-44 ejectors SPC (primary target) ⁸⁵	Supplementary method targeting goats and foxes not removed through other methods. Other species (rabbits, pigs) targeted opportunistically. Operations planned to occur during/after other pest management programs. ⁸⁶	✓ ?	Effective when used in combination with other methods ⁸⁷ Considered viable alternative method only when baiting not appropriate ⁸⁸	feral pig damage occurring on private neighbouring lands. ⁸³ "This planned night spot lighting operation, is to follow up the scheduled aerial baiting program, and the continuous M44 (CPE) program, and will target foxes as the primary pest, and also focus on other nocturnal pests animals, including feral cats and rabbits." ⁸⁹
	Goats	Reduce and suppress numbers	Trapping Mustering FAAST program SPC (primary target)	other pest management programs. ⁸⁶ Shoot Plan references Invasive Species CRC standard operating procedures.	✓	Most effective when used as follow-up to other control strategies ⁹⁰ Best suited to areas with high goat population ⁹¹	
	Rabbits	Reduce and suppress numbers	Warren ripping SPC (secondary target)		?	Rabbits are widespread in Central Mallee. Considered effective only when numbers are low ⁹²	
Yanga	Pigs	Reduce numbers	Trapping Ground shooting	Ground shooting by volunteers will target	✓	Useful as a complementary method to other forms of control ⁹³	"Ground shooting is a supplementary method of

⁸³ Office of Environment and Heritage, 2015, Cocopara SPC Shooting Operations Plan 02-06-2016 to 03-06-2016.

⁸⁴ NSW National Parks and Wildlife Service, 2015, Central Mallee Pest Management Site Plan.

⁸⁵ Ibid.

⁸⁶ Ibid.; Central Mallee SPC 28-04-15 to 30-04-15 Shooting Operations Plan.

⁸⁷ Pestsmart Connect, Invasive Species CRC, Fox Shooting and Hunting. Available at <http://www.pestsmart.org.au/fox-shooting-and-hunting/>, accessed on 04/09/2015.

⁸⁸ NSW Department of Primary Industries, Fox Control. Available at <http://www.dpi.nsw.gov.au/agriculture/pests-weeds/vertebrate-pests/pest-animals-in-nsw/fox-control>, accessed on 04/09/2015

⁸⁹ Office of Environment and Heritage, 2016, Central Mallee SPC Shooting Operations Plan 21-06-2016 to 22-06-2016.

⁹⁰ Pestsmart Connect, Invasive Species CRC, Ground Shooting of Feral Goats. Available at <http://www.pestsmart.org.au/ground-shooting-of-feral-goats/>, accessed on 04/09/2015.

⁹¹ Pestsmart Connect, Invasive Species CRC, Ground Shooting of Feral Goats. Available at <http://www.pestsmart.org.au/ground-shooting-of-feral-goats/>, accessed on 04/09/2015.

⁹² NSW Department of Primary Industries, Rabbit Control. Available at <http://www.dpi.nsw.gov.au/agriculture/pests-weeds/vertebrate-pests/pest-animals-in-nsw/rabbit-control>, accessed on 04/09/2015.

<p>- area staff SPC (primary target)</p>	<p>pigs, deer and rabbits not removed through other methods. Conducted in addition to ground shooting by area staff, which aims to reduce residual numbers after control programs have been implemented, or during water inundation events.</p>	<p>✓ Timed with other control activities to avoid disruption and dispersal to other areas⁹⁴ ? Effective only for managing small, isolated populations. Not considered suitable for landscape scale control⁹⁵ SPC shoot conducted in addition to other strategic ground shooting activities</p>	<p>controlling these species in specific areas of the reserves."⁹⁶</p>
<p>Deer Maintain current low level</p> <p>Ground shooting - area staff SPC (secondary target)</p>	<p>✓ Considered most effective control technique currently available for species⁹⁷ ? Best suited to targeting areas with high numbers⁹⁸ SPC shoot conducted in addition to other strategic ground shooting activities</p>	<p>✓ Considered most effective control technique currently available for species⁹⁷ ? Best suited to targeting areas with high numbers⁹⁸ SPC shoot conducted in addition to other strategic ground shooting activities</p>	<p>controlling these species in specific areas of the reserves."⁹⁶</p>
<p>Rabbits Reduce numbers</p> <p>Baiting Warren ripping Ground shooting - area staff SPC (primary target)</p>	<p>? Rabbits widespread in Yanga. Considered effective only when numbers are low⁹⁹ SPC shoot conducted in addition to other strategic ground shooting activities</p>	<p>? Rabbits widespread in Yanga. Considered effective only when numbers are low⁹⁹ SPC shoot conducted in addition to other strategic ground shooting activities</p>	<p>"Ground shooting is a supplementary method of controlling these pest species in specific areas of the reserves. [...] This plan is to</p>

⁹³ Pestsmart Connect, Invasive Species CRC, Practical Feral Pig Control. Available at <http://www.pestsmart.org.au/pestsmart-factsheet-practical-feral-pig-control/http://www.pestsmart.org.au/ground-shooting-of-feral-goats/>, accessed on 04/09/2015.

⁹⁴ NSW Department of Primary Industries, Feral Pig Control. Available at <http://www.dpi.nsw.gov.au/agriculture/pests-weeds/vertebrate-pests/pest-animals-in-nsw/feral-pig-control>, accessed on 04/09/2015

⁹⁵ Pestsmart Connect, Invasive Species CRC, Aerial and Ground Shooting for Feral Pig Control. Available at <http://www.pestsmart.org.au/shooting-for-feral-pig-control/>, accessed on 04/09/2015.

⁹⁶ Office of Environment and Heritage, 2015, Yanga SPC Shooting Operations Plan 15-07-2015 to 17-07-2015.

⁹⁷ Department of Agriculture and Fisheries, Feral Fallow Deer Factsheet. Available at https://www.daf.qld.gov.au/_data/assets/pdf_file/0005/69719/IPA-Fallow-Deer-Factsheet.pdf, accessed on 04/09/2015.

⁹⁸ Pestsmart Connect, Invasive Species CRC, Ground Shooting of Feral Deer. Available at <http://www.pestsmart.org.au/ground-shooting-of-wild-deer/>, accessed on 04/09/2015.

⁹⁹ NSW Department of Primary Industries, Rabbit Control. Available at <http://www.dpi.nsw.gov.au/agriculture/pests-weeds/vertebrate-pests/pest-animals-in-nsw/rabbit-control>, accessed on 04/09/2015.



	target)	activities
Goonoo	<p>Fox</p> <p>Reduce and maintain low numbers</p> <p>Ground baiting</p> <p>Spotlight shooting</p> <p>SPC (primary target)</p>	<p>follow up on a rabbit warren ripping program, conducted by NPWS throughout the NP & SCA.¹⁰⁰</p> <p>“Ground shooting is a supplementary method of controlling pest animals in identified areas of the reserve. This activity will supplement the other pest control programs in the reserve. The Regional Pest Management Strategy identifies management of fox as a critical priority for the protection of malleefowl.”¹⁰³</p> <p>✓ Effective when used in combination with other methods¹⁰¹</p> <p>Considered viable alternative method only when baiting not appropriate¹⁰²</p>
	<p>Goat</p> <p>Reduce numbers</p> <p>Exclusion (one-way gates)</p> <p>SPC (secondary target)</p>	<p>✓ Most effective when used as follow-up to other control strategies¹⁰⁴</p>
Gundabooka	<p>Goat</p> <p>Reduce numbers and limit activity</p> <p>Passive trapping</p> <p>Mustering</p> <p>Fencing</p> <p>Aerial shooting</p> <p>SPC (primary target)</p>	<p>“The [RPMS] identifies management of feral goats as a critical priority for the protection of [...] natural habitats and native flora and fauna. Ground shooting will supplement other pest control</p> <p>✓ Most effective when used as follow-up to other control strategies¹⁰⁶</p> <p>Undertaken following ground mustering and trapping activities. Focus on difficult to access areas, providing further opportunity to reduce numbers of shy</p>

¹⁰⁰ Office of Environment and Heritage, 2016, Yanga SPC Shooting Operations Plan 16-08-2016 to 19-08-2016.

¹⁰¹ Pestsmart Connect, Invasive Species CRC, Fox Shooting and Hunting. Available at <http://www.pestsmart.org.au/fox-shooting-and-hunting/>, accessed on 04/09/2015.

¹⁰² NSW Department of Primary Industries, Fox Control. Available at <http://www.dpi.nsw.gov.au/agriculture/pests-weeds/vertebrate-pests/pest-animals-in-nsw/fox-control>, accessed on 04/09/2015

¹⁰³ Office of Environment and Heritage, 2015, Goonoo SPC Shooting Operations Plan 29-04-2015 to 01-05-2015.

¹⁰⁴ Pestsmart Connect, Invasive Species CRC, Ground Shooting of Feral Goats. Available at <http://www.pestsmart.org.au/ground-shooting-of-feral-goats/>, accessed on 04/09/2015.



	Reduce numbers and limit activity	Fencing Aerial shooting SPC (secondary target)	or difficult to access pests. ¹⁰⁵	activities in the reserves. ¹⁰⁷
Pig	Reduce numbers and limit activity	Fencing Aerial shooting SPC (secondary target)	or difficult to access pests. ¹⁰⁵	<ul style="list-style-type: none"> ✓ Useful as a complementary method to other forms of control¹⁰⁸ ✓ Considered effective for managing small, isolated populations¹⁰⁹ ✓ Timed with other control activities to avoid disruption and dispersal to other areas¹¹⁰
Fox	Supress numbers	Baiting (not clear if there is a fox baiting program) SPC (secondary target)		<ul style="list-style-type: none"> ? Considered viable alternative method only when baiting not appropriate – not clear this is the case¹¹¹ Effective when used in combination with other methods¹¹²
Dog	Supress numbers	Baiting SPC (secondary target)		<ul style="list-style-type: none"> ? Considered an ineffective technique to reduce populations of wild dogs over extensive areas
Woomargama	Goats Reduce numbers	Aerial shooting SPC (secondary target)	"Utilised periodically throughout the year to maintain pest animal	<ul style="list-style-type: none"> ✓ Most effective when used as follow-up to other control strategies¹¹³

¹⁰⁶ Pestsmart Connect, Invasive Species CRC, Ground Shooting of Feral Goats. Available at <http://www.pestsmart.org.au/ground-shooting-of-feral-goats/>, accessed on 04/09/2015.

¹⁰⁵ NSW National Parks and Wildlife Service, 2015, Gundabooka NP & SCA Pest Management Site Plan.

¹⁰⁷ Office of Environment and Heritage, 2016, Gundabooka SPC Shooting Operations Plan 17-05-2016 to 20-05-2016.

¹⁰⁸ Pestsmart Connect, Invasive Species CRC, Practical Feral Pig Control. Available at [http://www.pestsmart.org.au/ground-shooting-of-feral-goats/](http://www.pestsmart.org.au/pestsmart-factsheet-practical-feral-pig-control/http://www.pestsmart.org.au/ground-shooting-of-feral-goats/), accessed on 04/09/2015.

¹⁰⁹ Pestsmart Connect, Invasive Species CRC, Aerial and Ground Shooting for Feral Pig Control. Available at <http://www.pestsmart.org.au/shooting-for-feral-pig-control/>, accessed on 04/09/2015.

¹¹⁰ NSW Department of Primary Industries, Feral Pig Control. Available at <http://www.dpi.nsw.gov.au/agriculture/pests-weeds/vertebrate-pests/pest-animals-in-nsw/feral-pig-control>, accessed on 04/09/2015

¹¹¹ NSW Department of Primary Industries, Fox Control. Available at <http://www.dpi.nsw.gov.au/agriculture/pests-weeds/vertebrate-pests/pest-animals-in-nsw/fox-control>, accessed on 04/09/2015

¹¹² Pestsmart Connect, Invasive Species CRC, Fox Shooting and Hunting. Available at <http://www.pestsmart.org.au/fox-shooting-and-hunting/>, accessed on 04/09/2015.

¹¹³ Pestsmart Connect, Invasive Species CRC, Ground Shooting of Feral Goats. Available at <http://www.pestsmart.org.au/ground-shooting-of-feral-goats/>, accessed on 04/09/2015.

Pigs	Reduce numbers	Aerial shooting Trapping SPC (primary target)	numbers at their current low densities. SPC ground shooting will target areas identified by monitoring as having higher pest densities as a means of preventing the reestablishment of pests within the reserve.”	<ul style="list-style-type: none"> ✓ Useful as a complementary method to other forms of control¹¹⁴ ✓ Targets areas known to support greatest densities ✓ Effective for maintaining low numbers¹¹⁵ ✓ Effective strategy when numbers are low¹¹⁷ 	<p>“Ground shooting is a supplementary method of controlling pest animals in identified areas of the reserve. This activity will supplement the other pest control programs in the reserve.”¹¹⁶</p> <p>“Ground shooting is a supplementary method of controlling pest animals in identified areas of the reserve. This activity will supplement the other pest control programs [...] Due to the current low abundance of these pest species they may not be impacting on the identified threatened species however the program will assist in keeping pest densities at low levels thus preventing significant impacts.”¹¹⁸</p>
Rabbits	Reduce numbers	Baiting/ fumigation SPC (primary target)			

¹¹⁴ Pestsmart Connect, Invasive Species CRC, Practical Feral Pig Control. Available at <http://www.pestsmart.org.au/pestsmart-factsheet-practical-feral-pig-control/http://www.pestsmart.org.au/ground-shooting-of-feral-goats/>, accessed on 04/09/2015.

¹¹⁵ NSW Department of Primary Industries, Feral Pig Control. Available at <http://www.dpi.nsw.gov.au/agriculture/pests-weeds/vertebrate-pests/pest-animals-in-nsw/feral-pig-control>, accessed on 04/09/2015

¹¹⁶ Office of Environment and Heritage, 2016, Woomargama SPC Shooting Operations Plan 20-08-2016 to 23-08-2016.

¹¹⁷ Pestsmart Connect, Invasive Species CRC, Ground Shooting of Rabbits. Available at <http://www.pestsmart.org.au/ground-shooting-of-rabbits/>, accessed on 04/09/2015.

¹¹⁸ Office of Environment and Heritage, 2015, Woomargama SPC Shooting Operations Plan 07-05-2015 to 08-05-2015.



3.3.4 Pest control by park neighbours

According to PMSPs, work by the NPWS is complemented by that done by Local Land Services (LLS) and, in some areas, by the pest control activities of park neighbours:

- Adjoining landholders conduct property scale pest control with LLS support in the Central Mallee. LLS and NPWS interact directly to undertake a landscape approach to pest management. NPWS keeps adjacent landholders notified of results.¹¹⁹
- One neighbour contributes to passive trapping program at Cocopara by maintaining fodder and watering points so as to attract goats through one-way gates. This program has been in place for five years and has removed on average 600 goats per year. Other adjoining landholders conduct property scale pest control with support from LLS.¹²⁰
- At Yanga, LLS and NPWS interact directly to undertake a landscape approach to pest management. NPWS keeps adjacent landholders notified of results.¹²¹
- Cross-tenure fox control program is in place at Goonoo, with baiting occurring across the reserve complex, in State Forest and on neighbouring land, coordinated by the LLS. NPWS also involve local community groups and general public in monitoring and reporting activities.¹²²
- Gundabooka have local Indigenous involvement in management through a Joint Management Advisory Committee. They conduct coordinated dog baiting with neighbouring properties and local community group, prompted by consultation with landholders. Fencing agreements are being negotiated with a number of neighbours to reduce movement of goats and stock.¹²³
- Neighbours of Woomargama NP monitor and report regularly to Park staff on pest management issues as they arise. They also contribute to wild dog control under the Hume Wild Dog Management Plan.¹²⁴

Landholders and park neighbours were consulted during formulation of RPMSs for all regions.

In phone surveys with neighbouring landholders in the Final Evaluation of the SPC Trial, at least 12 landholders referred to the pest management practices that they use on their properties bordering on parks and reserves, including the following techniques:

- baiting
- ground shooting
- trapping
- poisoning
- fencing
- maintaining buffer zones.

¹¹⁹ NSW National Parks and Wildlife Service, 2015, *Central Mallee Pest Management Site Plan*, p.1

¹²⁰ NSW National Parks and Wildlife Service, 2015, *Cocopara Pest Management Site Plan*, p. 1.

¹²¹ NSW National Parks and Wildlife Service, 2015, *Central Mallee Pest Management Site Plan*, p.1

¹²² NSW National Parks and Wildlife Service, 2015, *Goonoo Pest Management Site Plan*, p.1

¹²³ NSW National Parks and Wildlife Service, 2015, *Gundabooka NP & SCA Pest Management Site Plan*, p.1

¹²⁴ NSW National Parks and Wildlife Service, 2015, *Woomargama Pest Management Site Plan*, p.1.

"I shoot the pigs myself. The deer and the goats I can round up myself." (landholder phone survey, Goonoo neighbour)

"I've always done a fox baiting program when the ewes are lambing. A few years ago I did actually do some poisoning for feral pigs and it was successful I haven't seen any since." (landholder phone survey, Goonoo neighbour)

In these phone surveys, landholders also described some of the ways that their own pest control measures complement the NPWS pest management programs in their regions:

*"Fox numbers have reduced over last four years steadily. I think this is mainly because of the baiting programs myself and my neighbours have been undertaking, along with NPWS baiting programs".
(landholder phone survey, Gundabooka neighbour)*

"When [the NPWS] bait, I bait. So [the SPC trial] probably has changed the way I get rid of pest animals." (landholder phone survey, Yanga neighbour)

3.3.5 Details of objectives and priority species for SPC Trial sites

Table 13 below details the objectives of pest control programs in SPC reserves, together with key pest and threatened species. This table has been updated with additional evidence from the 2016 Shoot Plans since the alignment review undertaken as part of the Interim Evaluation in 2015.

Table 13. Objectives of pest control programs and key species in SPC management sections

SPC Trial site	What are the regional and national priorities for pest management for the site?	What are the aims and objectives of site level pest/threatened species management?	How do the PMSP and SPC Shoot Plans identify and document the highest priority pests?	What are the threatened species?
Central Mallee	<p>The RPMS outlines as a critical priority the protection of declining and threatened mallee woodland fauna through predation by foxes, and the protection of woodlands ecological communities through vegetation degradation and erosion through goats, rabbits and pigs.¹²⁵</p> <p>Central Mallee is listed as a priority site for management under the NSW Fox Threat Abatement Plan (TAP) for the protection of malleefowl, chestnut quail thrush, and southern scrub robin.¹²⁶</p> <p>Browsing by goats are a threat to the malleefowl listed in its National Recovery Plan.¹²⁷</p>	<p>The PMSP for Central Mallee identifies feral goats, foxes and rabbits as priority species, and pigs as a secondary species when conditions cause an increase in population. These species are targeted for their impacts on:</p> <ul style="list-style-type: none"> • Vegetation recovery, attributed to feral goats and rabbits • Reduction in native species including mammals and reptiles, in particular the SPRAT listed Malleefowl, as a result of predation by introduced foxes and native predator species.¹²⁸ <p>The Central Mallee PMSP also states: "Strategic pest animal control programs are one tool to</p>	<p>The PMSP for Central Mallee identifies feral goats, foxes and rabbits as priority species, and pigs as a secondary species when conditions cause an increase in population. The reduction of the numbers of these species in the Central Mallee reserve system is the main objective of the site plan. The Central Mallee PMSP refers to RMPS priority programs relating to target species. Shoot Plans identify compliance with the Central Mallee PoM, and with RMPS priorities. The PMSP states that SPC shooting activities primarily target foxes and goats, however Shoot Plans state that foxes and feral cats are the primary targets of shooting operations, with goats, pigs, rabbits and other pest animals listed as secondary targets. Shoot Plans refer to the impacts of primary and secondary target species: "Goats, pigs, rabbits & foxes [...] have a very large impact causing damage to natural habitats and impact heavily on native flora and fauna within these reserves. Curly Bark Wattle is</p>	<p>Malleefowl Southern Scrub Robin Chestnut Quail Thrush Redored Whistler Gilbert's Whistler Greycrowned Babler Brown tree Creeper Speckled warbler Varied sittella Hooded robin Shy heathwren Curly Bark Wattle (Acacia curranii) Ningau ywonneae (Marsupialia: Dasyuridae) Semi-arid woodlands¹³¹</p>

¹²⁵ Office of Environment and Heritage, 2012, Regional Pest Management Strategy 2012-2017: Western Rivers Region.

¹²⁶ Office of Environment and Heritage (OEH), Dec 2010, NSW Fox Threat Abatement Plan – Predation by the Red Fox (vulpes vulpes), OEH, Sydney.

¹²⁷ Benshemesh, J. 2007. National Recovery Plan for Malleefowl. Department for Environment and Heritage, South Australia.

¹²⁸ NSW National Parks and Wildlife Service, 2015, Central Mallee Pest Management Site Plan.

<p>Cocopara</p> <p>The RPMS outlines as critical priorities for Cocopara the protection of Pomaderris cocoparrana (ROTAP) and Inland Grey Box Woodland EEC through strategic goat and rabbit control.¹³²</p> <p>Feral goats were listed as the main threat to Pomaderris cocoparrana in the scientific determination of its listing as a Threatened species in NSW.¹³³</p>	<p>maintain acceptable species protection to allow species richness and abundance to be maintained.”¹²⁹</p> <p>Cocopara PMSP objectives include:</p> <ul style="list-style-type: none"> • Reduce feral goat numbers within Cocopara Nature Reserve • Maintain feral pig numbers at current low densities • Alleviate browsing pressure on Pomaderris cocoparrana and Inland Grey Box Woodland, and reduce land degradation • Reduce the impacts of pests to neighbouring properties¹³⁴ 	<p>an endangered species known to exist in two small locations in Yathong & Nombinnie. The latest information from Biodiversity & Wildlife Team would suggest these populations are struggling to survive due to heavy browsing, primarily by goats.”¹³⁰</p> <p>The PMSP identifies feral goats and pigs as priority species. Rabbits, foxes and cats are secondary priorities. SPC shooting activities target both priority species.</p> <p>The Cocopara PMSP references the RPMS feral pig, goat and rabbit priority programs for Cocopara and also notes, “Feral pigs are currently declared noxious pests under the Local Land Services Act 2013 which requires the land manager (NPWS) to continuously suppress and destroy them to minimise the risk of damage to the land.”¹³⁵</p> <p>The SPC Shoot Plans describe the economic and biodiversity impact of pigs and their reinvasion from neighbouring land, for example: “Feral pigs are a small intermittent problem in Cocopara NP/NR which, if left unchecked, have the potential to become a landscape issue. Pigs seem to mostly come from agricultural enterprise, although it is believed that some illegal seeding has occurred in neighbouring forests.”¹³⁶</p>	<p>Pomaderris cocoparrana Superb Parrot Turquoise Parrot Glossy Black Cockatoo Major Mitchell Cockatoo Painted Honeyeater Gilbert’s Whistler Shy Hyacola Chestnut Quail Thrush Common Wombats Grey Box Woodland EEC¹³⁷</p>
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¹³¹ NSW National Parks and Wildlife Service, 2015, Central Mallee Pest Management Site Plan, p. 1; Western Rivers Regional Pest Management Strategy, p. 11.

¹²⁹ NSW National Parks and Wildlife Service, 2015, Central Mallee Pest Management Site Plan, p. 1.

¹³⁰ Central Mallee SPC 28-04-15 to 30-04-15 Shooting Operations Plan.

¹³² Office of Environment and Heritage, 2012, Regional Pest Management Strategy 2012-2017: Western Rivers Region.

¹³³ Office of Environment and Heritage (OEH), NSW Scientific Committee Preliminary Determination: Pomaderris cocoparrana. <[http://www.environment.nsw.gov.au/resources/threatenedspecies/determinations/PDPomacocoE\\$.pdf](http://www.environment.nsw.gov.au/resources/threatenedspecies/determinations/PDPomacocoE$.pdf)>.

¹³⁴ NSW National Parks and Wildlife Service, 2015, Cocopara Nature Reserve Pest Management Site Plan, p. 1.

¹³⁵ NSW National Parks and Wildlife Service, 2015, Cocopara Nature Reserve Pest Management Site Plan, p. 1.

¹³⁶ Cocopara NR SPC 07-03-15 to 08-03-15 Shooting Operations Plan, p. 1.

¹³⁷ NSW National Parks and Wildlife Service, 2015, Cocopara Nature Reserve Pest Management Site Plan, p. 1; Cocopara NR SPC 07-03-15 to 08-03-15 Shooting Operations Plan, p. 3.



<p>Yanga</p> <p>The RPMS priorities for management of Yanga are to reduce threats to threatened species including the southern bell frog and migratory wetland birds through deer and pig control, and the protection of the Sandhill Pine Woodland EEC through rabbit control. Pest management at Yanga is also a priority for the protection of cultural and historic heritage. Strategic, continuous pig control program at Murrumbidgee NP is a flagship program under the Regional Plan.¹³⁸</p>	<p>The Yanga PMSP identifies pigs, deer and rabbits as priority pest species and its stated objectives are to reduce the impacts of vertebrate pests on:</p> <ul style="list-style-type: none"> • Migratory wetland birds • Southern bell frogs • Identified EECs • Neighbouring properties¹³⁹ 	<p>Feral pigs, deer and rabbits are identified as the priority species in the Yanga PMSP, and the primary target of SCP shooting activities. The Yanga PMSP describes the widespread impacts of rabbits and pigs, and references RPMS priority programs for pigs, deer and rabbits relating to Yanga and aligning with its planned pest control activities.¹⁴⁰ Shoot Plans identify compliance with the Yanga Plan of Management (POM), and identifies compliance with the RPMS relating to pig, deer and rabbit programs, and refer to alignment with the PMSP. The July 2015 Shoot Plan describes the impacts of pigs on the reserve: “[Pigs] have a very large impact, causing damage to natural habitats, native flora and fauna within these reserves.”¹⁴¹</p>	<p>Southern bell frog (Litoria raniformis) Migratory wetland birds Blue-billed and Freckled Ducks Spotted-tailed Quoll Australian Painted Snipe Major Mitchell Cockatoo Painted Honeyeater Sandhill Pine Woodland EEC Acacia melvillei Yarran Shrubland and Myall Woodland in the Darling Riverine Plains EECs Bush stone-curlew¹⁴³</p>
<p>The 2016 Shoot Plans state that “Rabbits in Yanga NP & SCA have a very large impact, causing damage to natural habitats and native flora and fauna within this reserve system. Ground shooting is a supplementary method of controlling these species in specific areas of the reserves. Other secondary target pest species that are listed in this plan will be targeted if seen while undertaking this program. This plan is following up on a warren ripping program conducted by NPWS staff throughout the NP & SCA, and also targeting pigs throughout the wetland areas”.¹⁴²</p>			

¹³⁸ Office of Environment and Heritage, 2012, Regional Pest Management Strategy 2012-2017: Western Rivers Region.

¹³⁹ NSW National Parks and Wildlife Service, 2015, Yanga Pest Management Site Plan.

¹⁴⁰ Ibid., p. 1.

¹⁴¹ Murrumbidgee Valley National Park & State Conservation Area (Yanga NP & SCA) SPC 15-07-15 to 17-07-15 Shooting Operations Plan.

¹⁴² Office of Environment and Heritage, 2016, Yanga SPC Shooting Operations Plan 29-02-2016 to 04-03-2016.



<p>Goonoo</p>	<p>According to the Northern Plains RPMS, Goonoo is considered a regional priority for fox control, and the Goonoo multi-stakeholder coordinated fox control program is a key regional program. The RPMS lists fox control is a critical priority for the site, aimed at protecting malleefowl and livestock from fox predation. Rabbits are a low priority target due to impact on native flora.¹⁴⁴ Goonoo is listed as a priority site for management under the NSW Fox Threat Abatement Plan (TAP) for the protection of malleefowl.¹⁴⁵ A Site Plan exists for the park and fox baiting activities have been conducted since 2001. Browsing by goats are a threat to the malleefowl listed in its National Recovery Plan.¹⁴⁶</p>	<p>Goonoo PMSP objectives are to:</p> <ul style="list-style-type: none"> • Reduce impacts of vertebrate pests on Malleefowl • Limit the impacts of pests to neighbouring properties • Maintain pests at low numbers • Reduce Goat numbers – thereby reducing habitat degradation/modification through goat browsing • Limit the spread of existing and/or emergent weeds 	<p>Foxes and feral goats specified targets of the PMSP and the SPC shooting activities. The PMSP refers to RPMS priorities for Goonoo Reserve Complex to reduce and maintain fox activity at low level and maintain malleefowl presence¹⁴⁷, and the Management Section's ongoing fox abatement work under the Fox Threat Abatement Plan (Fox TAP) since 2001. Shoot Plans indicate compliance with the Goonoo Plan of Management (POM), and the RPMS priorities for pest management in the Goonoo NP and SCA. All 2015 and 2016 Shoot Plans list foxes as the primary target and goats as a secondary target of SPC shooting operations. The April 2015 Shoot Plan states: "European red fox and other pest animal species have the ability to impact upon threatened species in Goonoo NP and SCA and Coolbaggie NR. Ground shooting is a supplementary method of controlling pest animals in identified areas of the reserve [...] The Regional Pest Management Strategy identifies management of fox as a critical priority for the protection of malleefowl. The program will assist in keeping pest densities at low levels thus preventing significant impacts. Goat, feral pig and deer are an emerging issues in the Goonoo complex. Rabbits, cats and dogs have been recorded on FoxtAP</p>	<p>Malleefowl</p>
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¹⁴³ Office of Environment and Heritage, 2012, Regional Pest Management Strategy 2012-2017: Northern Plains Region; NSW National Parks and Wildlife Service, 2015, Yanga Pest Management Site Plan; Murrumbidgee Valley National Park & State Conservation Area (Yanga NP & SCA) SPC 15-07-15 to 17-07-15 Shooting Operations Plan.

¹⁴⁴ Office of Environment and Heritage, 2012, Regional Pest Management Strategy 2012-2017: Northern Plains Region, p.3

¹⁴⁵ Office of Environment and Heritage (OEH), Dec 2010, NSW Fox Threat Abatement Plan – Predation by the Red Fox (vulpes vulpes), OEH, Sydney.

¹⁴⁶ Benshemesh, J. 2007. National Recovery Plan for Malleefowl. Department for Environment and Heritage, South Australia.

¹⁴⁷ NSW National Parks and Wildlife Service, 2015, Goonoo Pest Management Site Plan, p. 1.



<p>Gundabooka</p> <p>The Far West RPMS identifies the following critical priorities for Gundabooka:</p> <ul style="list-style-type: none"> Feral goat control for the protection of Curly-bark wattle Feral pig control to reduce impacts on neighbouring agriculture Wild dog control to reduce predation on neighbouring stock <p>The RPMS also lists fox control as a medium priority for the Park to reduce impacts on neighbouring stock and biodiversity.</p> <p>The Feral Goat TAP lists curly-bark wattle as species affected by competition and land degradation from unmanaged goats.¹⁴⁹</p>	<p>Gundabooka PMSP objectives are to:</p> <ul style="list-style-type: none"> Reduce goat activity within Gundabooka NP & SCA Maintain curly-bark wattle presence within the Gundabooka site Maintain Oldenlandia galioides, Rusty desert Pheballium and Mount vincent mintbush presence within the Gundabooka site Implement Regional Pest Management Strategy objectives. Monitor and implement control of new and emerging pest species (deer) Maintain exclusion of goats from rock art sites¹⁵⁰ 	<p>cameras. These species are included in this plan and will be targeted opportunistically.¹⁴⁸</p> <p>Feral goats, pigs, foxes and wild dogs are priorities in the Gundabooka PMSP. Goats are listed as the primary target for all SPC shooting operations in the 2015 and 2016 Shoot Plans provided. The PMSP notes RPMS priorities for Gundabooka regarding feral goats and protection of Curly-bark wattle EEC, as well as identification of other emergent threats by staff on-park.¹⁵¹</p> <p>Shoot Plans identify compliance with the Gundabooka POM, and the RPMS priorities for fox, pig and goat control for the Reserve.</p> <p>The July 2015 Shoot Plan states:</p> <p>“Feral goats in Gundabooka National Park (NP) and State Conservation area (SCA) impact upon natural habitats, native flora and fauna, and Aboriginal and European Heritage sites. The Regional Pest Management Strategy identifies management of feral goats as a critical priority for the protection of curly-bark wattle, rusty desert Pheballium, Mount Vincent mintbush and Oldenlandia galioides.”¹⁵²</p>	<p>Curly-bark wattle (Acacia curranii) Oldenlandia galioides Rusty desert Pheballium (Pheballium glandulosum) Mount vincent mintbush Prostranthera stricta 12 fauna species listed under the TSC Act 1995. (PMSP)</p>
<p>Woomargama</p> <p>The Southern Ranges RPMS</p>	<p>The Woomargama PMSP objectives</p>	<p>Feral goats, pigs and rabbits are the target species</p>	<p>Phantom Wattle</p>

¹⁴⁸ Goonoo SPC 29-04-15 to 01-05-15 Shooting Operations Plan.

¹⁴⁹ Department of the Environment, Water, Heritage and the Arts (DEWHA) (2008). Threat abatement plan for competition and land degradation by unmanaged goats, DEWHA, Canberra.

¹⁵⁰ NSW National Parks and Wildlife Service, 2015, Gundabooka NP & SCA Pest Management Site Plan, p. 1.

¹⁵¹ NSW National Parks and Wildlife Service, 2015, Gundabooka NP & SCA Pest Management Site Plan, p. 1.

¹⁵² Gundabooka NP & SCA SPC 26-07-15 to 29-07-15 Shooting Operations Plan., p.3.

<p>describes the critical priorities for pest management at Woomargama:</p> <ul style="list-style-type: none"> • Pigs and rabbits for protection of Phantom Wattle and Small Snake Orchid • Wild dogs and foxes for their predation on stock. <p>Pigs are a medium level priority for the site to reduce impact on neighbours' agriculture.¹⁵³</p> <p>The Woomargama National Park PoM notes that controlling pig populations is "a matter of priority" due to their impacts upon threatened native species.¹⁵⁴</p> <p>The National Recovery Plan for Phantom Wattle lists browsing by goats, pigs, rabbits and deer as a key threat, and lists management of these impacts as a recovery objective.¹⁵⁵</p>	<p>include:</p> <ul style="list-style-type: none"> • Reduce feral animal numbers within the reserve and prevent potential population increases across tenures. • Reduce the potential browsing impacts from feral animals. • Reduce the potential ground disturbance associated with feral animals in known locations of threatened species. <p>Management of the target species is also a high priority for protection of the site's cultural heritage assets.¹⁵⁶</p>	<p>identified in the 2015 PMSP, and goats and pigs are listed as primary targets of the SPC shooting activities. The 2015 PMSP further notes the Southern Ranges RPMS priorities for goats, pigs and rabbits for the protection of Phantom Wattle and Small Snake Orchid, and states:</p> <p>"Phantom wattle (<i>Acacia phasmoides</i>) is listed as Vulnerable, Threatened Species Conservation Act 1995 (TSC), where the only known population recorded in NSW exists near the southern boundary of Woomargama NP. Grazing, browsing and trampling are listed as a key threat to the population survival. Goats, pigs and rabbits have the potential to impact on this threatened species if populations are not controlled. The Small Snake Orchid, listed in the TSC as Endangered, has been recorded within the reserve, however was not identified prior to or during the development of the POM. Current threats to this species are similar to Phantom Wattle, however additional concerns exist where feral pigs may disturb or eat orchid tubers."¹⁵⁷</p> <p>In the updated PMSP provided for the current alignment review, it is unclear which species are the intended primary targets of SPC operations. Rabbits were the primary target of the March 2015 SPC shoot, and pigs were the primary target for all of the 2016 SPC shoots.</p>	<p>(<i>Acacia phasmoides</i>) Small Snake Orchid (<i>Diuris pedunculata</i>).¹⁵⁹</p>
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¹⁵³ Office of Environment and Heritage, 2012, Regional Pest Management Strategy 2012-2017: Southern Ranges Region.

¹⁵⁴ NSW National Parks and Wildlife Service, 2009, Woomargama National Park, Woomargama State Conservation Area, Mullengandra Nature Reserve and Mullengandra State Conservation Area Plan of Management, p. 22.

¹⁵⁵ Sutter, G. 2010. National Recovery Plan for Phantom Wattle *Acacia phasmoides*. Department of Sustainability and Environment, East Melbourne

¹⁵⁶ NSW National Parks and Wildlife Service, 2015, Woomargama Pest Management Site Plan, p. 1.

¹⁵⁷ NSW National Parks and Wildlife Service, 2015, Woomargama National Park Pest Management Site Plan, p. 1.

¹⁵⁹ Ibid.

Shoot Plans identify compliance with the Woomargama POM, and the Southern Ranges RPMS priorities for pig, goat and rabbit control for the Reserve, in particular as a critical priority for the protection of Phantom Wattle and Small Snake Orchid. The May 2015 Shoot Plan states: "Due to the current low abundance of these pest species they may not be impacting on the identified threatened species however the program will assist in keeping pest densities at low levels thus preventing significant impacts."¹⁵⁸

¹⁵⁸ Woomargama National Park SPC 07-05-15 to 10-05-15 Shooting Operations Plan, p.2.



Attachment 5: Survey questionnaire – reserve neighbours

Survey questionnaire – reserve neighbours

1. What reserves do you live the closest to e.g. share a boundary with? *Please select all that apply*

- Cocopara Nature Reserve
- Coolbaggie Nature Reserve
- Goonoo National Park
- Goonoo State Conservation Area
- Gundabooka National Park
- Gundabooka State Conservation Area
- Murrumbidgee Valley National Park (Yanga Precinct)
- Murrumbidgee Valley State Conservation Area
- Nombinnie Nature Reserve
- Nombinnie State Conservation Area
- Woomargama National Park
- Yathong Nature Reserve
- Yanga Complex
- Round Hill Nature Reserve

2. How important is the control of pest animals in NSW parks and reserves to you?

- Not at all important
- Slightly important
- Moderately important
- Very important
- Extremely important

3. Overall, how would you describe the impact of the following pest animals on you personally:

	Very beneficial	Beneficial	No impact	Detrimental	Very detrimental	Unsure	Not applicable
Foxes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Feral deer	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Feral goats	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Feral pigs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Rabbits	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wild dogs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other <i>please describe below</i>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other animal

4. How has the impact of the following pest animals on you changed since January 2014?

	Much better	Somewhat better	About the same	Somewhat worse	Much worse	Unsure	Not applicable
Foxes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Feral deer	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Feral goats	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Feral pigs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Rabbits	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wild dogs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other <i>please describe below</i>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other animal

5. Can you provide any examples of how the impacts of pest animals on you have changed since 2014 (if any)? If you have noticed a change, has this occurred over the past 12 months or has it been a general change since the commencement of SPC in 2014?

6. Overall, to what extent do you support pest animal control programs on NSW parks and reserves?

- Strongly oppose
- Somewhat oppose
- Neutral
- Somewhat support
- Strongly support
- Unsure

7. Overall, to what extent do you support ground shooting in NSW parks and reserves as a pest management technique?

- Strongly oppose
- Somewhat oppose
- Neutral
- Somewhat support
- Strongly support
- Unsure

8. Overall, to what extent do you support the use of qualified volunteers to control pest animals through ground shooting on NSW parks and reserves?

- Strongly oppose
- Somewhat oppose
- Neutral
- Somewhat support
- Strongly support
- Unsure

9. Overall, how satisfied have you been with the information provided to you by the National Parks and Wildlife Service about the SPC trial?

- Very dissatisfied
- Dissatisfied
- Neutral
- Satisfied
- Very satisfied
- Unsure
- Not applicable

10. Has the SPC trial changed the way you manage pests on your property? If so how?

11. From your experience, has the SPC trial changed the way that the National Parks and Wildlife Service, Local Land Services and landholders coordinate pest management? If so, how?

12. Over the course of the SPC trial, have you had any concerns about any aspects of the trial?

13. What were your concerns about the SPC Trial?

14. If you raised your concern with the National Parks and Wildlife Service, how satisfied were you with their response?

- Very dissatisfied
- Dissatisfied
- Neutral
- Satisfied
- Very satisfied
- Unsure
- Not applicable (didn't raise my concern)

Please feel free to elaborate

15. Has anything unexpected happened to you personally as a result of the SPC trial (positively or negatively)?

16. Are there any final comments you would like to make about the SPC trial?

Thankyou

Thank you very much for your time. Your feedback is valuable to the ongoing monitoring and evaluation of the SPC trial.

If you would like any further information about the National Parks and Wildlife Service please contact Craig Arms via email at Pest.Management@environment.nsw.gov.au

If you would like any further information about the Natural Resources Commission (NRC) or their independent evaluation of the SPC trial please visit www.nrc.nsw.gov.au or contact John Blanch (via email at SPC@nrc.nsw.gov.au or 02 9228 4552).

For more information about the SPC trial, please visit www.environment.nsw.gov.au/pestsweeds/spc.htm

Attachment 6: NPWS SPC Ecological and Operational Monitoring



Office of
Environment & Heritage
NSW National Parks & Wildlife Service



Supplementary Pest Control Trial 2014-2016 Ecological and Operational Monitoring

Version 1.3

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Abbreviations

The following abbreviations are used throughout this document:

AMS	Asset Maintenance System
DPI	Department of Primary Industries
EEC	Endangered Ecological Community
FAAST	Feral Animal Aerial Shooting Team
Fox TAP	NSW Fox Threat Abatement Plan
LLS	Local Land Services
NP	National Park
NPWS	National Parks and Wildlife Service
NR	Nature Reserve
OEH	Office of Environment and Heritage
PWIS	Pest and Weed Information System
RPMS	Regional Pest Management Strategy
SAP	Systems Applications and Products
SCA	State Conservation Area
SF	State Forest
SOS	Saving Our Species Program
SPC	Supplementary Pest Control
TAP	Threat Abatement Plan
WHS	Work Health and Safety

1 Introduction

1.1 Background

In mid-2013, the NSW Government decided to:

- Implement a program of Supplementary Pest Control (SPC) in selected national parks and other reserves, using volunteer licensed shooters under direction and supervision of National Parks and Wildlife Service (NPWS) staff;
- Commence the program initially as a 3-year trial in 12 reserves (see Figure 1 and sec 4); and
- Undertake an evaluation of the 3-year trial to assess and report on its effectiveness before any further rollout of the program.

1.2 SPC Program Goal

To assist the control of pest animals by supplementing NPWS pest control programs through appropriately qualified volunteer shooters.

1.3 Desired Outcomes of SPC Trial

- A. Safe implementation of SPC operations.
- B. Pest animals controlled in trial reserves in a way that enhances other NPWS pest programs in reducing impacts on the environment and neighbouring landholders.
- C. Respectful relationships between NPWS and volunteer shooters and associated organisations, who find their participation rewarding.
- D. Community informed of and appropriately engaged in the SPC trial.
- E. Robust evidence-based measures of effectiveness, benefits and costs of the trial program, sufficient to inform decisions about proceeding with the program.

1.3.1 SPC Effectiveness, Benefits and Costs

This document presents the SPC methodology aimed at measuring effectiveness of the trial and its integration into existing pest management (point 1.3E). Data collected will help answer key questions about the merits of the SPC trial program. The primary high-level questions are:

- Did the trial work?
 - Has the SPC trial assisted the effectiveness of existing NPWS pest control programs in minimising the impact of pest animals on the environment and neighbouring landholders? If yes, to what extent and what are the key success factors?
 - What is the evidence that relevant native species populations have been additionally protected by the SPC trial? This will partly rely on existing NPWS monitoring in the 12 reserves, already used for reporting for *NSW 2021 A Plan to Make NSW Number One*.

- What is the evidence that impacts on neighbouring landholders from pest animals have been reduced?
- How many pest animals did volunteers remove and what contribution has this made in complementing numbers of animals controlled through existing NPWS pest control activities? (This includes consideration of relative timing of control activities).
- Has the SPC trial been operationally integrated into existing NPWS pest animal programs? If yes, what are the key success factors in achieving this? Have there been any negative impacts of the trial on other NPWS park operations? What improvements should be made to operating procedures?
- Have good animal welfare standards been maintained?
- Has the SPC trial been conducted in a manner that minimises identified risk and is compliant with relevant legislation?
- Was the trial worth it?
 - What have been the overall costs and benefits of this trial to the NSW Government and to the relevant regional economies?
- Social impacts
 - What have been the (positive or negative) social impacts of the trial, taking into account the views of park neighbours, relevant Aboriginal communities, Local Land Services, shooters involved in the trial, other members of the hunting community, conservation and animal welfare groups, and tourism providers?
- How could the SPC program be improved to be more efficient and effective?
 - What has been learnt during the course of the trial?
 - Which elements should continue, which elements should be modified and which elements should be discontinued if the program is rolled out after the trial has finished?

As much reliable evidence as possible will be gathered to answer each of these questions. For some questions (e.g. recovery of native species populations) conclusive, scientifically reliable evidence at all sites may not be achievable within the trial timeframe.

2 Governance

OEH will conduct the trial, utilising its established adaptive management framework, which is being applied to similar evaluations of new park management techniques such as ecological thinning and grazing.

Any scientific papers produced as part of the trial will be peer reviewed, and appropriate scientific rigour will be managed in accordance with the OEH Scientific Rigour Position Statement.

3 Timeframe

The trial commenced in January 2014 and will proceed for three years. The Natural Resources Commission (NRC) are conducting the evaluation of the trial program. The data collected as per this document will be provided to the NRC as part of their evaluation. The NRC will provide an evaluation report to the NSW Minister for the Environment at the conclusion of the trial.

4 The SPC Trial Reserves

The SPC trial is being conducted in 12 reserves predominantly in western NSW (Figure 1). Where reserves are adjacent or in close proximity to each other they have been considered as a single complex for the purpose of the evaluation. This resulted in complexes (see Figure 1 and Table 1).

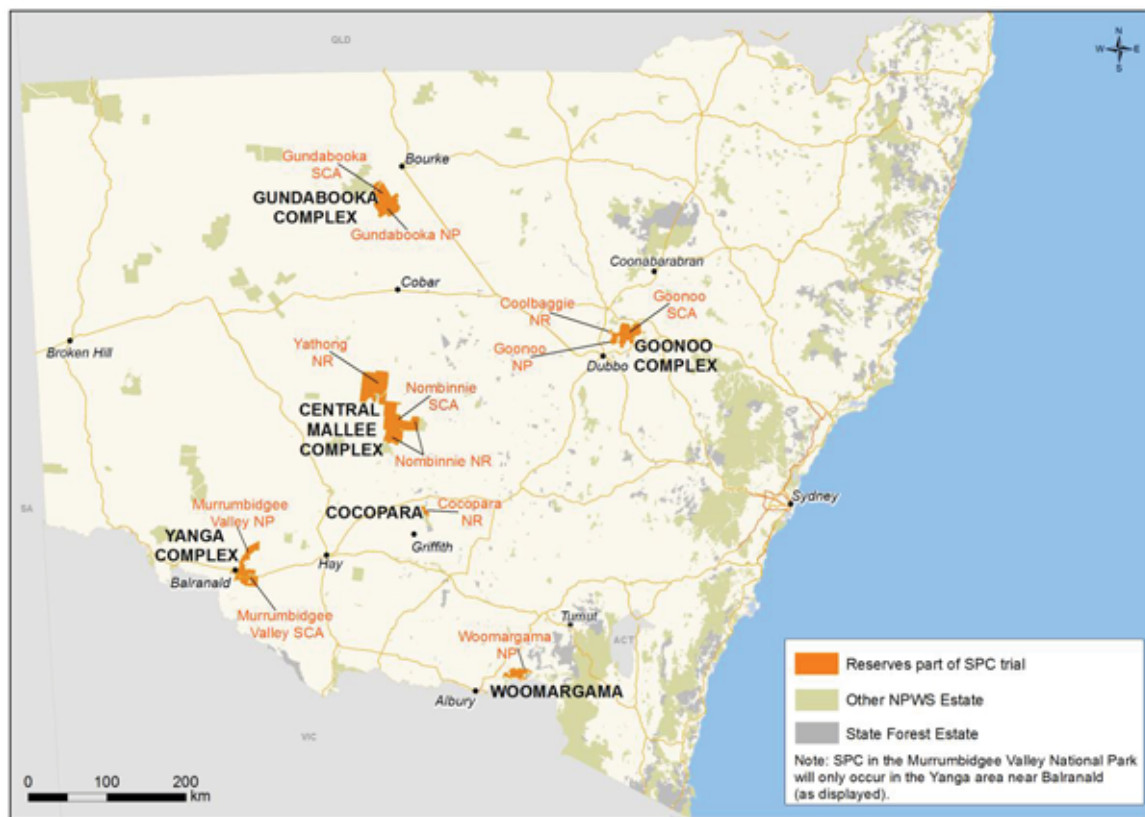


Figure 1 SPC Trial Complexes and the reserves that are contained within them.

Table 1 SPC Trial Reserves

Complex Name	Reserves	NPWS Area	NPWS Region
Gundabooka	Gundabooka NP Gundabooka SCA	Bourke	Far West
Goonoo	Goonoo NP Goonoo SCA Coolbaggie NR	Coonabarabran	Northern Plains
Central Mallee	Yathong NR Nombinnie NR Nombinnie SCA	Mid West	Western Rivers
Cocopara	Cocopara NR	Mid West	Western Rivers
Yanga	Murrumbidgee Valley NP Murrumbidgee Valley SCA	South West	Western Rivers
Woomargama	Woomargama NP	Riverina Highlands	Southern Ranges

5 Ecological Monitoring of SPC

5.1 Limitations of vertebrate pest monitoring

The primary function of monitoring vertebrate pest management programs is to indicate whether the program is achieving its objectives (Hone 1994). The information gathered is then used to determine if there is a need to adapt the methodology used for both the management program and the monitoring system. The objectives of the management program are therefore imperative in determining what type of monitoring will be undertaken.

The ecological objective of SPC is to assist with the effectiveness of existing NPWS vertebrate pest control programs in minimising the impact of pest animals on identified threatened species and ecological communities. In order to determine if this is being achieved two things need to be monitored:

- Threatened species recovery
- Vertebrate pest abundance

Each reserve that has been selected for the SPC trial has threatened species or endangered ecological communities which are being protected by ongoing vertebrate pest control programs. Ideally, measuring the responses of threatened species recovery to these pest control programs involves monitoring at treatment and nil-treatment sites (Quinn and Keough 2002; Underwood 1997). However, there is a lack of suitable nil-treatment sites for the SPC trial complexes due to a range of factors. There are two main factors that preclude suitable nil-treatment sites: 1) Lack of comparable reserves due to the small amount of areas of land under conservation in Western NSW (where the 6 SPC complexes are located) - the selection of areas for conservation somewhat compounds this issue as uniqueness is often a key reason for conservation status thereby making the reserve intrinsically different; 2) The large differences in pest animal population and pest control techniques. This means the baseline pest population as well as pressures from pest control vary greatly between reserves making these populations unfit for comparison. One or both of these factors exist for each of the SPC complexes preventing the use of nil-treatment sites in the SPC evaluation.

There are also limitations to measuring threatened species recovery: 1) generally low abundance/distribution of the threatened species, difficulty in differentiating the impact of other species, and the slow recovery time of the threatened species. Due to these limitations, it was deemed impractical to empirically survey threatened species recovery and to adopt other measures. However in two of the SPC complexes (Cocoparra and Central Mallee), the impacts on threatened species will be monitored either directly (such as monitoring activity at malleefowl mounds) or with surrogate measures (such as browsing of abundant plants as a surrogate of browsing on *Cocoparra pomaderris*).

Estimates of the absolute abundance of wild animals are costly, and not practical for some species (such as foxes) and are largely unnecessary for measuring changes in population abundance (Caughley 1980). Indices of abundance of the vertebrate pest

itself will be used as an indication of pest impacts, with a relationship between population size, population indices, and impact (where it isn't being measured directly) assumed (Edwards *et al.* 2004; Mitchell and Balogh 2007a). Sample counts will be used to provide indices to infer trends in vertebrate pest abundance, details of count methodologies for each SPC complex are provided in following sections.

Since nil-treatment sites are not being used in the SPC evaluation, effects of factors such as rainfall, climatic variation, other exotic species, and other management actions will need to be considered by other means. Data from other sources such as the Bureau of Meteorology and existing NPWS pest data bases will be used to add context to abundance indices. In the SPC complexes where goats are the target pest species, the macropod activity will be recorded concurrently to help tease out the effectiveness of goat management practices. For example, a decline in goat activity while macropod activity remains stable or increases likely indicates that goat management in that area is being effective. .

Given the consideration above, the species monitored and the techniques used for the SPC trial will vary between locations. Indices of abundance and/or activity will be used rather than absolute counts. In reserves that already have existing monitoring programs (e.g. for Fox TAP or SOS purposes) those programs will be utilised.

After 12 months of monitoring has been completed for the SPC trial the data will be reviewed and any changes required to the methodology will be implemented.

5.2 Gundabooka Complex

5.2.1 Brief Description of the Reserves and Threatened Species

The Gundabooka Complex is made up of Gundabooka NP and Gundabooka SCA and is located in the semi-arid environment of north western NSW. It is approximately 50 km south-west of Bourke and 110 km north-west of Cobar. The climate is characterised by hot summers and mild winters with annual average rainfall of 350 mm, although this is highly variable.

Gundabooka Complex contains Mount Gunderbooka, the Gunderbooka Range and surrounding slopes and plains to the north, east and west, and the Darling River to the north. The park is located at the northern end of the Cobar Penneplain biogeographic region. The area of land dedicated to the maintenance of biodiversity within this biogeographic region is small. The complex is isolated from other protected areas and surrounded by pastoral lands. In this context it provides valuable habitat for native flora and fauna.

The vegetation is dominated by open woodland, and there are populations of four threatened plant species. Two of these plants, the desert phebalium (*Phebalium glandulosum*) and Mount Vincent mint bush (*Prostanthera stricta*), are small/medium shrubs that are restricted to small areas of the range. Both have been heavily grazed by introduced herbivores. Sweet false gallium (*Hedyotis galioides*) is a rare annual herb that has only been recorded in the Gunderbooka range. The curly-bark wattle (*Acacia curranii*) is a small tree with a very limited and disjunct distribution. A population of approximately 150 trees has been recorded on Mount Gunderbooka. Surveys for this species within the park indicate that it only occurs on two small areas on Mount Gunderbooka. Goat control has been listed as critical for curly-bark wattle conservation in the Regional Pest Management Strategy for Far West Region (OEH 2012a).

Three threatened mammal species have been recorded in the complex: the little pied bat (*Chalinolobus picatus*), yellow-bellied sheath-tail-bat (*Saccolaimus flaviventris*) and the kultarr (*Antechinomys langieri*). The little pied bat is distributed across western NSW and roosts in caves, rock outcrops and tree hollows. The yellow-bellied sheath-tail-bat has been recently recorded at several sites in western NSW. It roosts in large tree hollows and forages for airborne insects above the canopy of wooded habitats. The main threats to populations of both these species are thought to be clearing and predation at roost sites by cats. The kultarr has always been rare in western NSW, and is found in ground and log hollows in a wide variety of vegetation types. The main threats to this species are fire, land degradation, flooding, predation and cultivation.

Three threatened bird species have been recorded; the pink cockatoo (*Cacatua leadbeateri*), pied honeyeater (*Certhionyx variegatus*) and painted honeyeater (*Grantiella picta*). Pink cockatoos are found sporadically in woodland and tree-lined watercourses over a wide area of western NSW and beyond. They depend on fresh surface water and tree hollows. The main threats to their populations are clearing, grazing (which inhibits regeneration of future nesting trees) and illegal trapping. Pied honeyeaters, although widespread across arid and semi-arid woodlands, are rarely

seen. They follow rain and flowering shrubs, predominantly various species of *Eremophila*. They are threatened by a reduction of food supplies through the clearing of shrubland/woodland. Painted honeyeaters are distributed across western NSW, mainly throughout forested drainage lines and are dependent on the fruiting patterns of mistletoe (*Amyema* spp.) infestations. The threats to this species are largely unknown, however competition with other species, clearing and selective thinning of infected trees may all be factors (DEC 2005).

5.2.2 SPC Target species

Goats are the primary target for SPC in the Gundabooka complex. They are listed in the current Far West Regional Pest Management Strategy (RPMS) as a critical threat to the survival of the curly-bark Endangered Ecological Community (EEC) (OEH 2012a). Secondary targets most likely to be encountered are pigs, wild dogs, foxes, cats and rabbits.

5.2.3 Vertebrate Pest Monitoring

Goats will be the primary vertebrate pest species monitored as part of the ecological monitoring of the SPC trial in the Gundabooka Complex. Records of other pest species shot will be kept as part of the operational monitoring (see sec. 6).

Monitoring of goats across large spatial areas in Australia is often undertaken using aerial surveys (Mitchell and Balogh 2007d; Pople and Froese 2012). In NSW, goats have been counted in the western rangelands as part of OEH's Kangaroo Management Program (KMP) annual and ongoing aerial surveys since 1993 (Ballard et al. 2011). Transects for these surveys are approximately 50 km apart based on latitude (ie 2 transects per degree of latitude). However, this type of operation is expensive and must be carried out by trained observers. Untrained observers have been known to see only 10% - 30% of the number of animals of trained observers (Lethbridge et al. 2013b). Consequently, it was decided to use alternative monitoring methods for goats in Gundabooka to facilitate the continuation of this monitoring program regardless of the outcome of the SPC trial.

Goats leave conspicuous sign of their presence, namely dung, and counting this can be an alternative to estimating their actual abundance (Triggs 2004). Pellet count transects are a well-established method for monitoring goat activity (Lethbridge *et al.* 2013b, 2013a; Mitchell and Balogh 2007d; Russell *et al.* 2011) and can also indicate if other pest species are becoming a problem. Therefore pellet count transects will be used to monitor changes in goat activity in the Gundabooka Complex. Macropod dung will also be recorded to help determine the effects of factors not being measured such as climatic influences.

Motion-triggered cameras will also be used in grid formations on Mt Gunderbooka, partly due to the ruggedness of the terrain and difficulties of conducting pellet counts here, but also to gain a different insight to goat activity in this part of the reserve. Mt Gunderbooka has strong cultural values and numerous art sites. Some of these art sites have been protected from goats entering overhangs and rubbing up on the rockwalls, however not all sites have been protected and it is also assumed that not all sites have been recorded. After consultation with the Gundabooka Joint

Management Committee, one grid was established in close proximity to known art sites, one around the curly-bark wattle population and a third which includes a gorge of cultural significance.

Pellet Counts

- Transects are located across the reserve with the exception of Mt Gunderbooka. These transects target known and reliable waterpoints, but are not within 200m of the waterpoint in order to alleviate bias due to goats temporal persistence at these locations.
- Transects are 100m long and 2m wide and marked with pegs at the start and end point to allow accurate re-sampling. The direction of transects was determined using randomly generated compass bearings. Start and end point coordinates were recorded with unique identifiers.
- All fresh dung 1m either side of transects will be counted and recorded by species according to Triggs *et al.* (2004). Macropod dung in the Gundabooka Complex cannot be accurately differentiated and as a result data for these animals are pooled. Data is recorded using a Trimble Juno handheld computer with CyberTracker software installed.
- Counts are conducted in autumn and spring each year.

Motion-Triggered Cameras

- Cameras are located in 3 grids of 12 on Mt Gunderbooka. One grid is around art sites, with the other two grids around curly-bark wattle locations and a culturally significant gorge. The cameras are approximately 750m apart.
- One Reconyx PC800 Hyperfire camera is permanently attached to a suitable tree using a cablelock at each of the sampling points. The set up is such that the camera is not facing the rising or setting sun, at a height of approximately 1m and with a very slight downwards angle.
- Fresh batteries and SD cards are put in each camera for a minimum of 14 consecutive nights in autumn and spring each year coinciding with the pellet counts.
- Cameras are passive set (ie no bait or other attractants will be used) and are programmed to take 5 images per trigger event with a 5 second delay between each image. There is a 60 second delay between trigger events. These settings have been designed with goats in mind as they have a propensity to camp in front of cameras compared to other pest species such as foxes which move rapidly through their home range (B. Mitchell and A. McSorley, personal observations).
- After the completion of the minimum deployment time SD cards are retrieved and the images downloaded.
- Images are tagged using ExifPro software for analysis



Figure 2 Goats walking in front of a motion-triggered camera on Mt Gunderbooka (SPC)

5.2.4 Threatened Species Monitoring

Curly-bark wattle monitoring is being undertaken as part of the OEH Saving Our Species Program. 3 large exclosures have been constructed to keep goats away from the majority of curly-bark wattles. Monitoring of resilience and recruitment of the wattle, both inside and outside the exclosures, occurs once per year.



Figure 3 Mature curly-bark wattle within one of the exclosures on Mt Gunderbooka (S.Thornton)

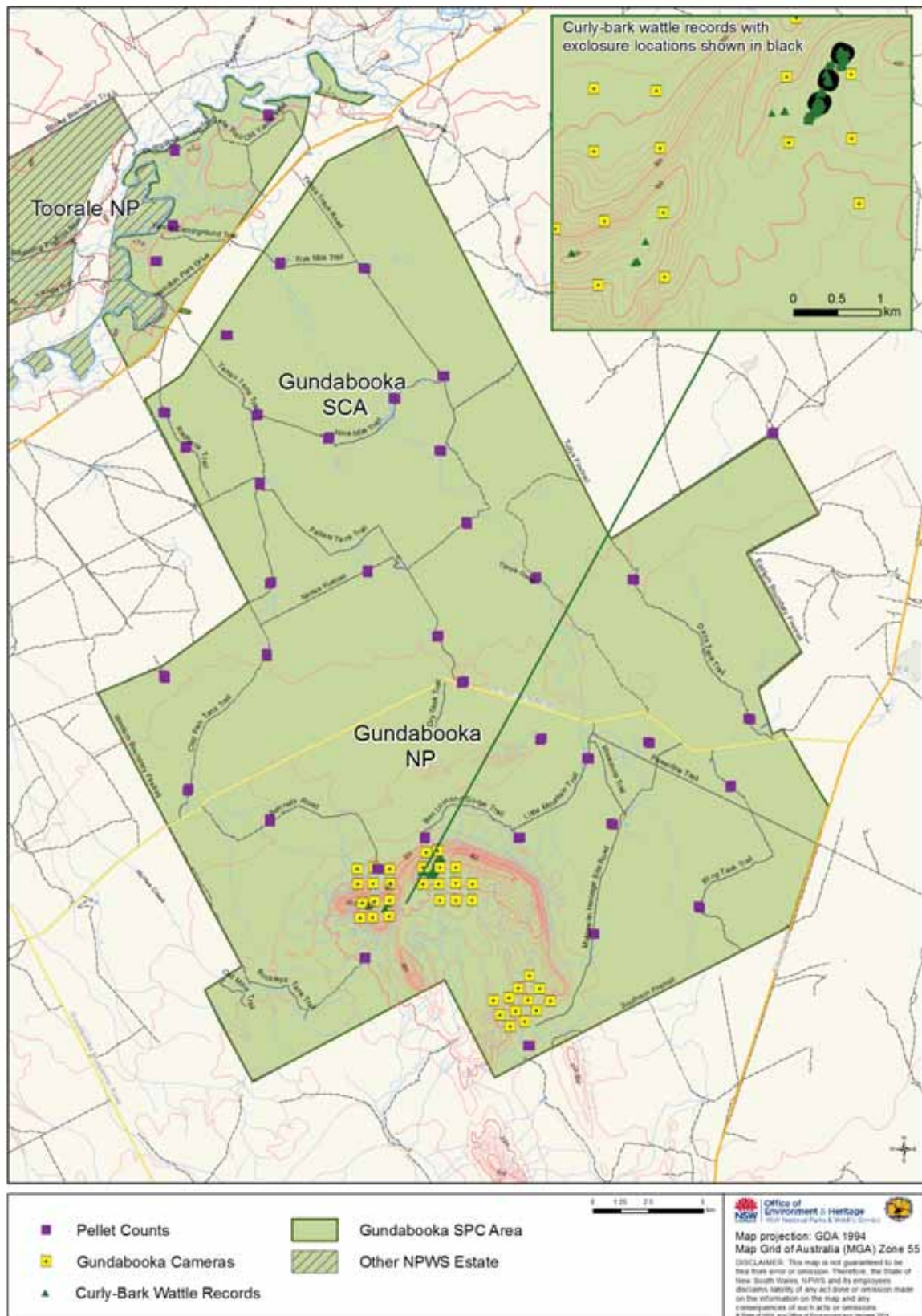


Figure 4 Gundabooka Complex showing monitoring locations and curly-bark wattle records

5.3 Goonoo Complex

5.3.1 Brief Description of the Reserves and Threatened Species

The Goonoo Complex is made up of three reserves: Goonoo NP, Goonoo SCA and Coolbaggie NR, and encompasses 65 000 ha of the southern end of the Brigalow Belt South Bioregion. The climate is characterised by hot summers and cool winters, with an average annual rainfall of 600 mm.

The land surrounding the Goonoo complex is a mix of grazing and intensive farming agricultural land. Dubbo is located 30 km to south-west, Gilgandra 40 km north-west and Dunedoo 40 km east of the complex.

The Goonoo Complex supports communities of narrow leafed ironbark and white cypress on poor sandy soils and black cypress on silt stones. Congoo mallee and green mallee predominate in the mallee areas. White mallee also exists in small stands at its eastern most extent. One EEC is found within the complex, the Inland Grey Box Woodland.

There have been five threatened plant species recorded within the Goonoo Complex: *Tylophora linearis*, Keith's Zieria (*Zieria ingramii*), *Rulingia procumbens*, scant pomaderris (*Pomaderris queenslandica*) and *Homoranthus darwinioides*. These species are threatened by habitat degradation, track maintenance activities and grazing by rabbits and goats (OEH 2013a).

Seventy-seven bird species have been recorded with the Goonoo Complex with twenty-two of them listed as threatened. These include malleefowl (*Leipoa ocellata*), glossy black-cockatoo (*Calyptorhynchus lathami*), speckled warbler (*Chthonicola sagittata*) and Gilbert's whistler (*Pachycephala inornata*). The malleefowl population in the Goonoo Complex is the eastern-most population in NSW and is spatially isolated from other malleefowl populations. It is particularly vulnerable to local extinction due to the small local population size, threats to nesting and forage habitat and its isolation. The Goonoo forests have been a priority site for the Fox TAP since 2001 and a comprehensive fox control and malleefowl monitoring program is in place to reduce malleefowl predation by foxes and monitor the breeding success of the local malleefowl population (DECCW 2010).

5.3.2 SPC Target species

Foxes are the primary target for SPC in the Goonoo Complex. They are listed in the Northern Plains Regional Pest Management Strategy (RPMS) as a critical threat to the survival of malleefowl (OEH 2012b). Secondary targets are, but not limited to, goats, rabbits, pigs, deer, wild dogs and cats. Goats are an emerging threat in the Goonoo complex and pose a significant risk to malleefowl due to habitat degradation.

5.3.3 Vertebrate Pest Monitoring

Foxes and goats will be monitored as part of the SPC trial in the Goonoo Complex. Records of other pest species shot will be kept as part of the operational monitoring (see sec. 6).

Foxes

The Goonoo Complex is within the Goonoo Fox TAP site, which has an established monitoring program for foxes. Therefore, this existing program is being utilised for the SPC trial at these reserves. Motion-triggered cameras are being used to monitor the presence of foxes at sampling points throughout the Goonoo Complex. There are 100 monitoring sites located on a 5km grid pattern across the TAP site with 40 of these sites located on NPWS estate and managed by NPWS staff. The other 60 sites are on private property surrounding the reserves and will be managed by the Central West Local Land Services (LLS).

Monitoring on NPWS reserves is being implemented in June/July & December each year. The June/July monitoring is undertaken prior to a cooperative baiting program in July. One camera is positioned at each monitoring site and set up according to the methods set out in the Goonoo Fox TAP Site Plan. Cameras are used to record activity for 14 nights at each site.

The cameras are a mix of Reconyx RC60 and Reconyx HC500 and have the same settings and setup to ensure consistency in data collection. All NPWS images taken are being catalogued using Portfolio (software program) to allow for analysis. Central West LLS are providing the raw data from their cameras to NPWS for analysis.

Goats

Pellet count transects will be used to monitor changes in goat activity in the Goonoo Complex. Goats are in very low numbers (David Wurst, Northern Plains Pest Management Officer personal communication, 2014) and as such aerial surveys would be unsuitable. The most conspicuous sign of goat presence may not always be the animals themselves but rather their dung, especially when they are at low densities (Triggs 2004). Pellet count transects are a well-established method for monitoring goat activity (Lethbridge *et al.* 2013b, 2013a; Mitchell and Balogh 2007d; Russell *et al.* 2011) and can also indicate if other pest species are becoming abundant. Macropod dung will also be recorded to help determine the effects of factors not being measured such as climatic influences.

Data from the first survey of goats in the Goonoo Complex confirmed the low abundance of these animals in the reserve. In order to increase the sensitivity of the count to detect change additional pellet count transects were established around reliable waterpoints within the complex.

Pellet Counts

- Transects are located in two ways in the Goonoo Complex: 40 transects are randomly allocated (but within 500m from a vehicular access point to allow timely sampling) and 44 transects are located around 11 reliable waterpoints creating a square formation.

- Transects are 100m long and 2m wide and marked with pegs at the start and end point to allow accurate re-sampling. Start and end point coordinates were recorded with unique identifiers.
- All fresh dung 1m either side of transects will be counted and recorded by species according to Triggs *et al.* (2004). Macropod dung in the Goonoo Complex cannot be accurately differentiated and as a result data for these are pooled. Data is recorded using a Trimble Juno handheld computer with CyberTracker software installed.
- Counts are conducted in autumn and spring each year



Figure 5 Pellet count set up, Goonoo Complex (B.Mitchell)

5.3.4 Threatened Species Monitoring

As part of the Goonoo Fox TAP site, the Goonoo Complex has an established monitoring program for malleefowl. Therefore, this existing program will be utilised for the SPC trial at these reserves.

Motion-Triggered Camera Monitoring

Prior to the breeding season each year, cameras will be set up at each known mound to capture any malleefowl activity. Once active mounds for the season have been identified, cameras will then be set up on the active mounds to monitor breeding behaviour and (potentially) reproductive success i.e. egg laying and chicks hatching, as well as visitation to the mounds by other species. Cameras will be attached to a steel post or tree within 5 metres of the mound at a height of 1-2 metres and programmed to take still and/or video footage of activities around mounds. Cameras will be revisited every 4-6 weeks to change batteries and memory cards.

Bi-annual Monitoring for inclusion into the National Malleefowl Monitoring Database

All known mounds on NPWS estate within the site will be monitored bi-annually using the National Malleefowl Monitoring Database (NMMD). NPWS will liaise with LLS and landholders to undertake monitoring on private land using NMMD. The database aims to record the details (including the location, size, age and activity status) of mounds across Australia.

The data collected via the above methods will be used locally to provide an indication of Malleefowl presence / absence within the site and to monitor the persistence of breeding pairs at mounds. This work is currently being undertaken with assistance from staff in the Biodiversity Conservation Unit in Dubbo.

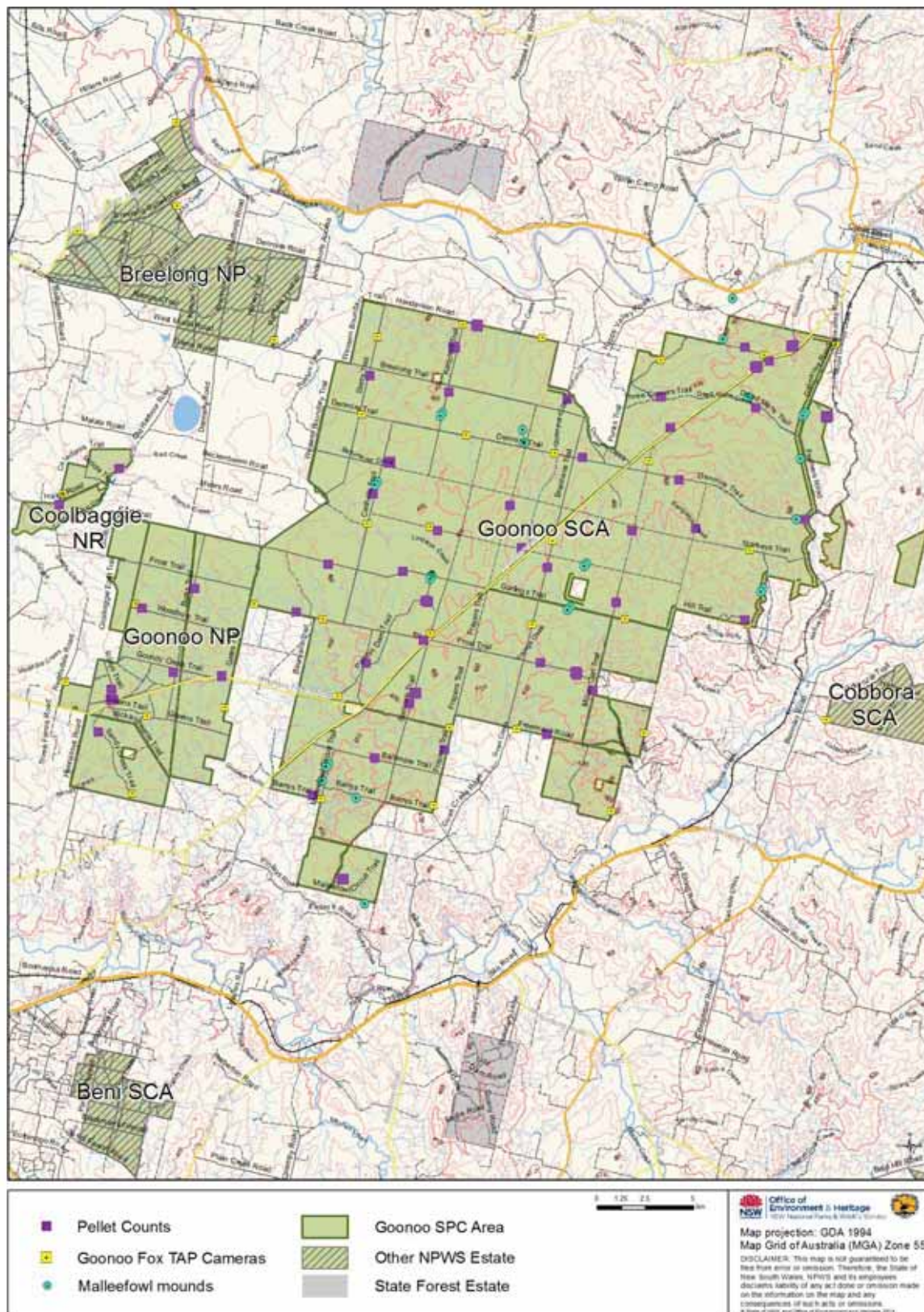


Figure 6 Goonoo Complex showing malleefowl mounds

5.4 Central Mallee Complex

5.4.1 Brief Description of the Reserves and Threatened Species

The Central Mallee Complex is a large contiguous area (230 000 ha) comprising three reserves located in central NSW: Yathong NR, Nombinnie NR and Nombinnie SCA. The complex is on the boundaries between three major biophysical regions; the Cobar Peneplain, the Darling Depression and the Southern Riverine Plain. The resulting geography of ranges, hills, rolling downs and lowlands, plains and dunefields gives the area great diversity of landscape and habitat. The major landscape feature of the complex is the Merrimerrriwa Range, which rises to 200m above the plains. The climate is characterised by hot summers and mild winters with an average annual rainfall of 400 mm.

The surrounding district is used for grazing (mainly sheep) and dryland wheat farming. The nearest village is Mount Hope (20 km east), with the complex remote from any large towns. Cobar (north), Condobolin (east) and Griffith (south) are all approximately 150 km away.

The Central Mallee Complex protects the largest remaining stand of mallee in NSW, a vegetation community which has been subject to large scale clearing for grain cropping and has been severely diminished in NSW. Mallee communities contain a variety of plant species, many of which show preference for specific soils, from sandy dunes to plains and old clayey drainage depressions. The large and varied area of the Central Mallee Complex therefore protects a wide range of species and habitats. In addition, the complex contains areas of woodland habitats typical of central NSW such as white cypress pine (*Callitris glaucophylla*), bimble box (*Eucalyptus populnea*), black box (*E. largiflorens*) and belah (*Casuarina cristata*). These communities have also been widely cleared for grazing and cropping in the region (NPWS 1996b).

Rare and endangered plant species occurring in the complex include the threatened curly-bark wattle (*Acacia curranii*), wild lime (*Eremocitrus glauca*), common sour-bush (*Choretrum glomeratum*), western wedding-bush (*Ricinocarpus bowmanii*), iron-grass (*Lomandra patens*), yellow darling pea (*Swainsona laxa*) and *Phebalium obcordatum*. A number of species are near the limit of their range, for example brigalow (*Acacia harpophylla*), which is near its southern limit and azure daisy-bush (*Olearia rudis*) which is at its easterly limit. The survival of the curly-bark wattle in particular is threatened by grazing from goats (Genevieve Wright, NPWS Flora Ecologist personal communication, 2014; (OEH 2014).

The Central Mallee Complex is a major area of habitat for two threatened native mammals: the southern Ningai (*Ningai yvonneae*) a mouse sized carnivore and kultarr (*Antechinomys laniger*). Threats to these animals are predation by foxes and cats and heavy grazing and trampling of habitat and food resources by goats and rabbits (NPWS 1996b).

Six threatened bird species have been recorded in the Central Mallee Complex: malleefowl (*Leipoa ocellata*), striated grass wren (*Amytornis striatus*), red-lored whistler (*Pachycephala rufogularis*), Gilbert's whistler (*Pachycephala inomata*), southern scrub robin (*Drymodes brunneopygia*) and chestnut quail thrush

(*Cinclosoma castanotum*). Threats to the survival of these species include habitat loss and predation by foxes and cats. Central Mallee Complex is also a Fox TAP site for the protection of these species (NPWS 2001; OEH 2011).

5.4.2 SPC Target species

Foxes and goats are the primary target for SPC in the Central Mallee Complex. They are both listed in the Western Rivers RPMS as a critical threat to the survival of malleefowl and other mallee birds (OEH 2012d). Goats are also a critical threat to the curly-bark wattle (OEH 2012d). Secondary targets are, but not limited to, cats, rabbits, pigs, deer and wild dogs.

5.4.3 Vertebrate Pest Monitoring

Foxes and goats are the vertebrate pest species monitored as part of the ecological monitoring of the SPC trial in the Goonoo Complex. Records of other pest species shot will be kept as part of the operational monitoring (see sec. 6).

Foxes

The Central Mallee Complex is within the Central Mallee Fox TAP site which has an established monitoring program. However, parts of this monitoring program were planned but unfunded. Therefore, SPC will assist with this shortfall and carry out two different programs aimed at foxes. Spotlighting will be used in areas where mallee vegetation is absent or sparse. This technique has been used for many years to survey foxes, can cover large areas in a short amount of time and is relatively simple to do (Mitchell and Balogh 2007b; Saunders *et al.* 1995; Sharp *et al.* 2001; Vine *et al.* 2009). Spotlighting was also chosen as it can be done concurrently with the goat monitoring (see below). Motion-triggered cameras will also be used to monitor the presence of foxes, and other fauna, at sampling points established on vehicular tracks in areas of known malleefowl activity.

Spotlight Counts

- There will be 4 spotlight count transects along suitable trails in Central Valley (Yathong NR) and Nombinnie NR & SCA (see Figure 9).
- Transect lengths are a minimum of 20km in length.
- Spotlight count must start approximately 30 minutes after sunset from an established start point.
- One person drives a 4WD vehicle at a constant slow speed (10-15 kmh) while the observer, positioned in the front passenger seat) scans a 90° arc ahead of the vehicle with a window mounted spotlight and counts pest animals and macropods seen. The vehicle may be paused in order to obtain a positive identification.
- Data is to be recorded using a Juno Trimble handheld computer with CyberTracker software installed.
- Repeat the count on three consecutive nights of similar weather (not in high wind or rain).

- Subsequent counts must start at the same time as the first count, follow the same route (direction and distance) and use the same equipment and observers.

Cameras

- There will be 80 monitoring sites in two separate areas (40 cameras in each area) of known malleefowl activity along vehicular tracks. The cameras are approximately 1.5km apart (see Figure 9).
- One Reconyx PC800 Hyperfire camera is securely attached to a star post driven into the ground at each of the sampling points. The set up is such that the camera is not facing the rising or setting sun, at a height of approximately 1m and with a very slight downwards angle.
- Each camera is set for a minimum of 14 consecutive nights. Timing of deployment is pre-fox baiting in February/March and in Spring.
- Cameras are passive set (ie no bait or other attractants will be used) and are programmed to take 3 rapidfire images per trigger event. These settings have been designed to maximise the chance of capturing species which may move rapidly past a camera.
- After the completion of the minimum deployment time the cameras are retrieved and the images downloaded.
- Images are tagged using ExifPro software for analysis



Figure 7 Fox and malleefowl walking past passive set cameras set in the Central Mallee SPC Complex (SPC)

Goats

Goat monitoring in the Central Mallee complex will consist of vehicular based daylight counts. Macropod numbers will also be recorded to help determine the effects of factors not being measured such as climatic influences. This method was chosen as (similarly to spotlighting) it can cover large areas in a short amount of time, is relatively simple to do, and it can be done concurrently with other monitoring in the complex (Mitchell and Balogh 2007d; Parkes *et al.* 1996). This method is also relatively easy to maintain over many years. Aerial surveys were

considered but not undertaken due to costs and the uncertainty of future funding for ongoing monitoring.

- There will be 4 daylight count transects that overlap with the spotlight count routes
- Transect lengths are a minimum 40km in length
- Daylight counts occur on the same days as the spotlight counts and must start from an established start point between 0800-1000 so that they are completed such that they do not influence the spotlight counts.
- One person drives a 4WD vehicle at a constant slow speed (20-40 kmh) while the observer, positioned in the front passenger seat scans ahead of the vehicle and counts pest animals and macropods seen. The vehicle may be paused in order to obtain an accurate number of animals when seen in large groups.
- Data is to be recorded using a Juno Trimble
- Repeat the count on the three consecutive mornings of the spotlight counts
- Subsequent counts must start at the same time as the first count, follow the same route (direction and distance) and use the same equipment and observers.

5.4.4 Threatened Species Monitoring

Malleefowl

Central Mallee Aerial Survey

Aerial surveys will be conducted by NPWS Ecosystems and Threatened Species Team and will be limited to locating known and new malleefowl mounds in the Central Mallee with resources primarily to go to surveying Yathong NR. Yathong has the most data available from past aerial surveys to help in identifying population trends in response to management. Surveys in Round Hill NR will be a second priority if resources allow, as this reserve is also part of the Central Mallee Fox TAP site and may provide valuable data on malleefowl breeding.

Central Mallee mound monitoring – Motion-triggered Cameras

The camera trap project, run by NPWS Ecosystems and Threatened Species Team, aims to capture image data from a representative sample of the malleefowl population on Yathong NR. From historical knowledge there may be up to 12 or 15 mounds active during a good breeding season. Currently the project aims to capture data from an entire breeding season, with data analysis expected to provide guidance on the longer term value of continuing monitoring beyond the first year period (including recommendations for cost efficiency measures).

Red-lored whistler

Point surveys are undertaken across the Central Mallee complex targeted towards red-lored whistler as part of the SOS program run by NPWS Ecosystems and Threatened Species Team. Information on non-target species, including chestnut

quail thrush, southern scrub robin and Gilbert's whistler are also recorded. 15 minutes are spent at each point; with 3 minutes of listening to get some data on how many birds are calling voluntarily; 4 minutes playing red-lored whistler calls; and 8 minutes listening for a response.

Curly-bark wattle

Curly-bark wattle is known to occur in a small area in the south of Yathong Nature Reserve. A recent survey by the NPWS Biodiversity and Wildlife Team has found that goats are browsing on these plants. Follow up surveys by the Biodiversity and Wildlife Team are planned for 2015 and will look at resilience and recruitment of this curly-bark population.



Figure 8 Curly-bark wattle browsed, stripped and broken by goats in Yathong NR (G.Wright)

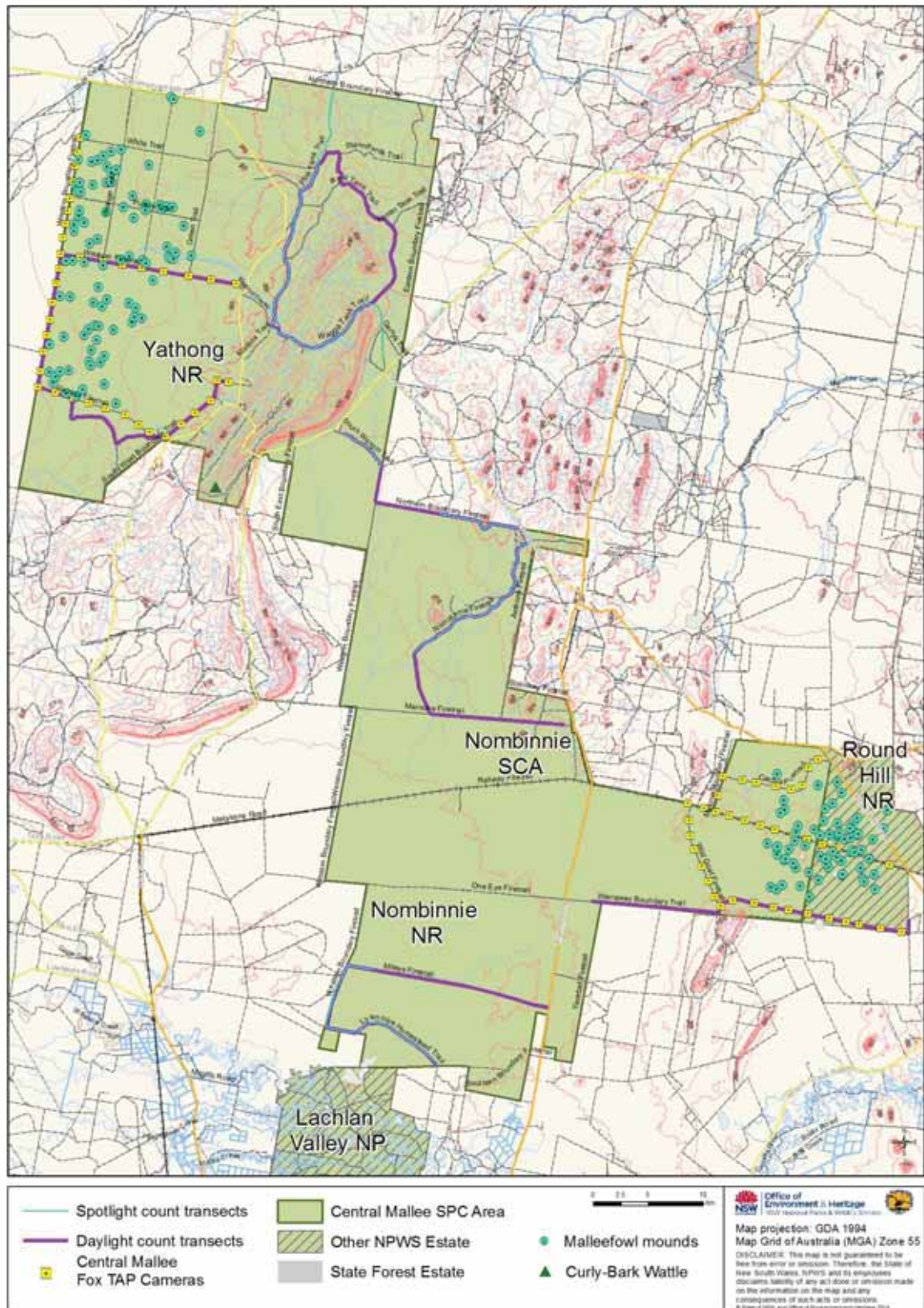


Figure 9 Central Mallee Complex showing monitoring locations and threatened species information.

5.5 Cocopara Nature Reserve

5.5.1 Brief Description of the Reserves and Threatened Species

Cocopara Nature Reserve is located about 25 km northeast of Griffith in the Riverina District of southern NSW. The climate is characterised by warm summers and cool winters with annual average rainfall of 420 mm. This small reserve encompasses almost 5 000 hectares and is bounded at the northern and southern ends by Conapaira South State Forest and Cocoparra National Park respectively.

Cocopara NR is made up of the high, dry broken landscape of the Cocoparra Range and is almost surrounded by cleared agricultural land, including the intensively developed irrigation area to the south. The principal vegetation communities include black cypress, currawang, dwyer's gum and red stringy bark with box woodlands on lower and more fertile slopes. The plains were previously covered in mallee or an acacia or pine/box woodland and the patches of vegetation on the valley floors of the range are scarce remnants of this formerly extensive woodland of the plains.

Cocopara NR provides refuge for a number of plant and animal communities that are typical of the semi-arid ranges of this part of NSW. The Cocoparra Range is close to the most westerly limit of distribution for a large number of plant and animal species which occur more commonly on the southern tablelands or in cypress pine woodlands of the western slopes and ranges. It is also the easterly limit of species which occur on the western plains (NPWS 1996a).

Threatened plant species or communities occurring in the reserve include the Cocoparra pomaderris (*Pomaderris cocoparrana*), a medium-sized shrub found in sensitive rock outcrop environments, and Inland Grey Box Woodland EEC. Threats to these plants and communities are primarily grazing by goats and rabbits.

There have been eight vulnerable bird species recorded in Cocopara NR: the painted honeyeater (*Grantiella picta*), superb parrot (*Polytelis swainsonii*), turquoise parrot (*Neophema pulchella*), glossy black cockatoo (*Calyptorhynchus lathamii*), chestnut quail-thrush (*Cinlosoma castanotum*), Gilbert's whistler (*Pachycephala inornata*), shy hylacola (*Sericornis cautus*) and pink cockatoo (*Cacatua leadbeateri*). The glossy black cockatoos found within the reserve are at the southern extent of the endangered glossy black-cockatoo, Riverina Population.

5.5.2 SPC Target species

Goats are the primary target for SPC in Cocopara NR. They are listed in the Western Rivers RPMS as a critical threat to the survival of the Cocoparra pomaderris and Inland Grey Box Woodland EEC (OEH 2012d). Secondary targets are, but not limited to, rabbits, pigs, deer, wild dogs, foxes and cats.

5.5.3 Vertebrate Pest Monitoring

Goats will be monitored as part of the ecological monitoring of the SPC trial in Cocopara NR. Records of other pest species shot will be kept as part of the operational monitoring (see sec. 6).

Aerial surveys in Cocopara NR were not considered due to the reserve's small size and steep relief. Therefore pellet count transects will be used to monitor changes in goat activity in this area. Macropod dung will also be recorded to help determine the effects of factors not being measured such as climatic influences.

Pellet counts

- 40 transects randomly located across the reserve. Reserve stratified into two areas by topography: gullies and other. Transects are within a ½ hr walk from the nearest vehicle access point to allow timely sampling.
- Transects are 100m long and 2m wide and marked with pegs at the start and end point to allow accurate re-sampling. Start and end point coordinates were recorded with unique identifiers.
- All fresh dung 1m either side of transects will be counted and recorded by species according to Triggs *et al.* (2004). Macropod dung in the Cocopara cannot be accurately differentiated and as a result data for these are pooled. Data is recorded using a Trimble Juno handheld computer with CyberTracker software installed.
- Counts are conducted in autumn and spring each year

5.5.4 Vertebrate Pest Impact Monitoring

The Cocoparra pomaderris, *Pomaderris cocoparrana*, is threatened by grazing from goats however its distribution in the Cocopara NR is poorly recorded. Therefore, browsing of indicator plants will be used to monitor goat impact (Lethbridge *et al.*, 2013). A minimum of four indicator plant species that are palatable to goats, well distributed and common within the reserve, easy to identify, long-lived and woody will be selected to monitor over time. The condition of individual plants will be used to generate an index of browsing pressure. Plants with height >2m will be avoided for monitoring purposes as they have effectively 'escaped' the browse zone of goats. Indicator plants should also have a mixture of life stage (e.g. seedling, juvenile, and adult). A minimum of 40 of each indicator species will be required (Lethbridge *et al.*, 2013).

Browse class and Growth form monitoring

In order to ease re-location indicator plants will be used as close to pellet count transects as possible.

- Indicator plants will be permanently marked using steel land markers with white caps
- Each plant will be examined for browsing and the following data recorded:
 - Growth form of the plant:
 - Unaffected (no or very little browsing (ie just tips missing))
 - Recovering (new shoots emerging from browsed stock but are not browsed)

- Affected (hedged form, new shoots from browsed stock are browsed)
- Heavily affected (death of all stems previously browsed and new growth emerging from lower stem)
- Browse class of the plant (the average diameter of all previously browsed stem tips):
 - Intact (no browsing)
 - Toothpick (< 1.5mm)
 - Matchstick (1.5-3 mm)
 - Drink straw (3.1mm-5mm)
 - Pencil (6-9mm)
 - Little finger (10-15mm)
 - Thumb (15-25mm)



Figure 10 Cocoparra pomaderris with significant browsing (A. McSorley)

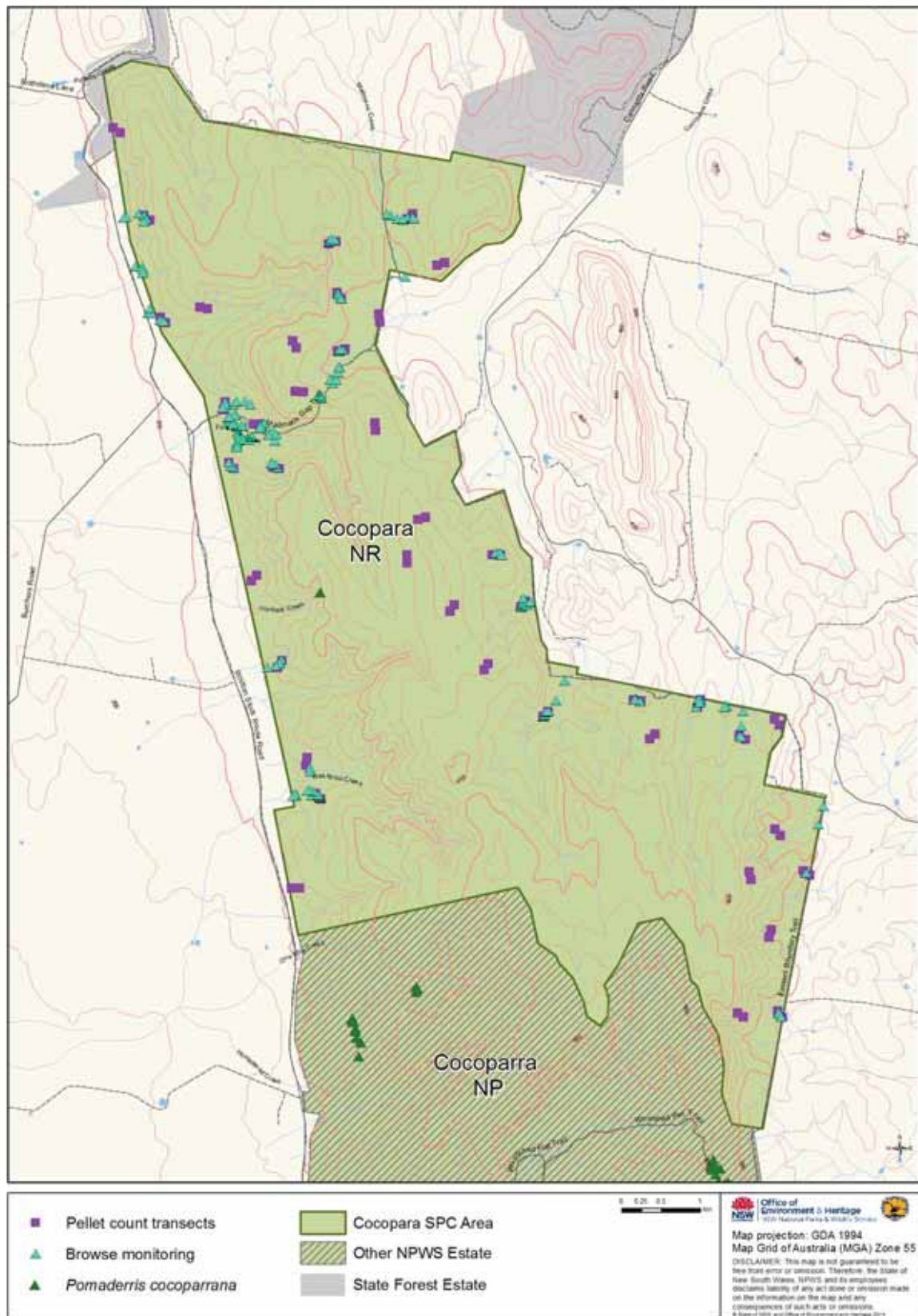


Figure 11 Cocopara Nature Reserve showing SPC monitoring and Cocoparra pomaderris records

5.6 Yanga Complex

5.6.1 Brief Description of the Reserves and Threatened Species

The Yanga Complex is located in south-western NSW at the western edge of the Riverina agricultural region, approximately 50 kilometres from the Victorian border. The nearest towns are Balranald (8 kilometres to the west), Hay (134 kilometres to the east) and Swan Hill (114 kilometres to the south in Victoria). The complex is made up of the Murrumbidgee Valley SCA and the Yanga Precinct of the Murrumbidgee Valley NP. This area encompasses approximately 70 000 hectares and has hot summers and mild winters, with an average rainfall of 300 mm.

Land use surrounding the Yanga complex includes dry-land and irrigated cropping (cereal crops, rice, cotton, lupins, faber beans, corn, sorghum), grazing of natural and improved pastures, and private forestry harvesting.

The Yanga Complex has a diverse assemblage of vegetation including river redgum forests and woodlands, wetlands, chenopod shrublands, Acacia shrublands, arid woodlands and Mallee environments. Three EECs occur within the complex: Sandhill Pine Woodland; *Acacia melvillei* Yarran Shrubland; and, Myall Woodland. Two endangered plant species occur within the complex: winged peppergrass (*Lepidium monoplocoides*) and Austral pipewort (*Eriocaulon australasicum*). Threats to these plants survival include habitat degradation and grazing by rabbits.

Sixteen threatened bird species have been recorded in the Yanga Complex including the bush stone-curlew (*Burhinus grallarius*), the eastern subspecies of the regent parrot (*Polytelis anthopeplus monarchoides*), and the painted snipe (*Rostratula benghalensis australis*) (Wen *et al.* 2011). The wetlands found within the complex also host 12 bird species listed on international migratory bird agreements and two threatened amphibians: the southern bell frog (*Litoria raniformis*) and Sloane's froglet (*Crinia sloanei*) (OEH 2013b). Threats to the survival of these species include habitat degradation or loss and predation by pigs and foxes.

5.6.2 SPC Target species

Pigs, deer and rabbits are the primary targets for SPC in the Yanga Complex. Pigs and deer are listed in the Western Rivers RPMS as a critical threat to migratory wetland birds and the southern bell frog, while rabbits are a critical threat to the Sandhill Pine EEC (OEH 2012d). Secondary targets are, but not limited to, goats, wild dogs and foxes.

5.6.3 Vertebrate Pest Monitoring

Pigs, deer and rabbits are being monitored as part of the ecological monitoring of the SPC trial in the Yanga Complex. Records of other pest species shot will be kept as part of the operational monitoring (see sec. 6).

Spotlighting is being used to monitor all primary pest species. This technique has been used for many years for these animals, can cover large areas in a short amount of time and is relatively simple to do (Choquenot *et al.* 1993; Cruz *et al.* 2013; Engeman *et al.* 2013; Fletcher *et al.* 1999; Mitchell and Balogh 2007c, 2007a; Twigg

et al. 1998). This method is also relatively easy to maintain over many years. Aerial surveys were considered but not undertaken due to costs and the uncertainty of future funding for ongoing monitoring.

Spotlight Counts

- There are 5 spotlight count transects along suitable trails in the Yanga Complex (see Figure 12).
- Transect lengths are a minimum of 15km in length.
- Spotlight counts must start approximately 30 minutes after sunset from an established start point.
- One person drives a 4WD vehicle at a constant slow speed (10-15 kmh) while the observer, positioned in the front passenger seat) scans a 90° arc ahead of the vehicle with a window mounted spotlight and counts pest animals and macropods seen. The vehicle may be paused in order to obtain a positive identification.
- Data is being recorded using a Juno Trimble handheld computer with CyberTracker software installed.
- Count is repeated on three consecutive nights of similar weather (not in high wind or rain).
- Subsequent counts must start at the same time as the first count, follow the same route (direction and distance) and use the same equipment and observers.

5.6.4 Threatened Species and Impact Monitoring

Waterbirds

Waterbird ground surveys are conducted bi-monthly as part of environmental flow monitoring conducted by OEH and Charles Sturt University and also coincide with the annual Eastern Australia Waterbird Survey run by the University of NSW.

Southern bell frog

Broad-scale surveys for tadpoles and adult frogs, along with assessments of aquatic and terrestrial habitat, and water quality are conducted throughout the year by OEH in conjunction with Charles Sturt University.

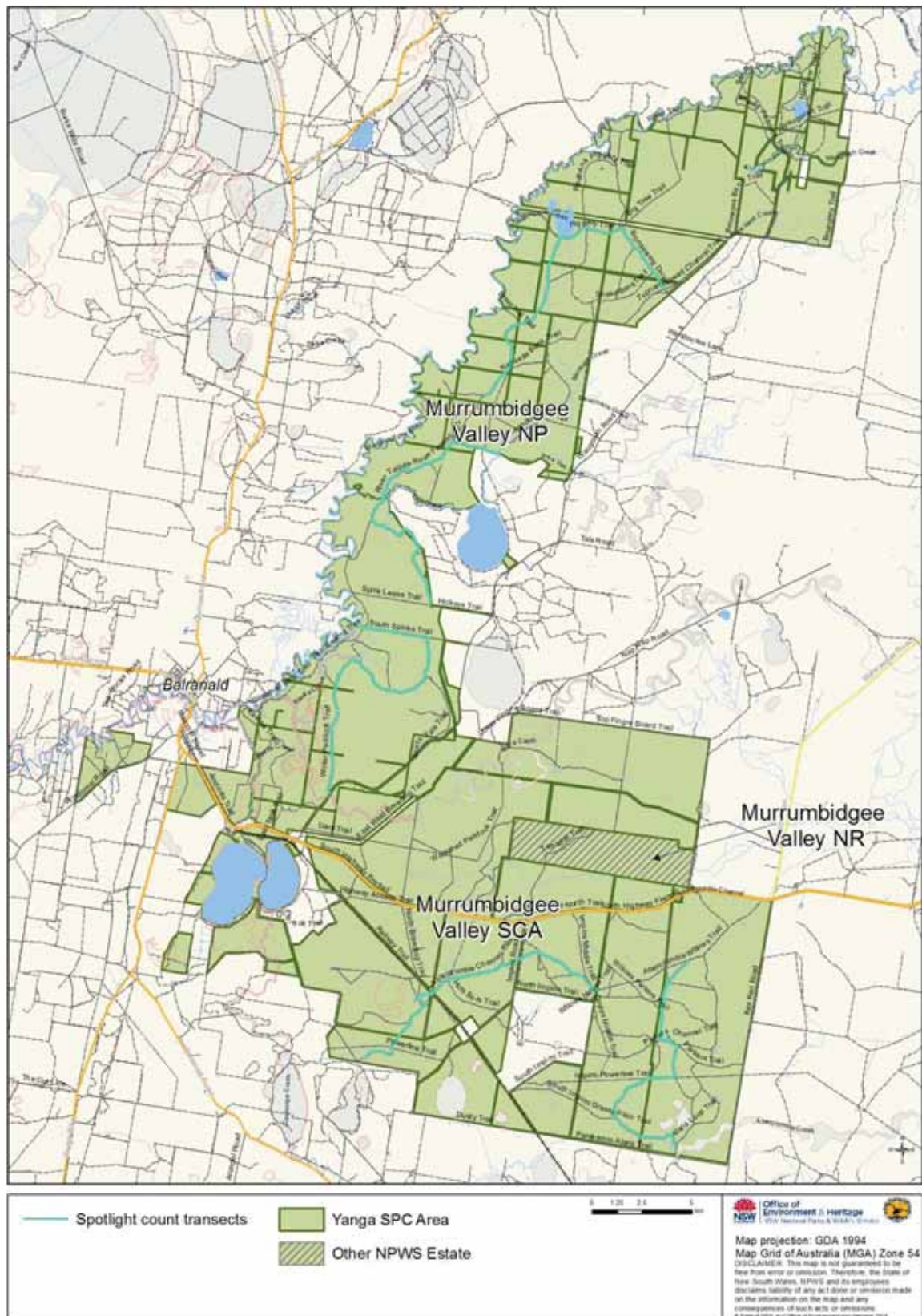


Figure 12 Yanga Complex showing SPC monitoring

5.7 Woomargama National Park

5.7.1 Brief Description of the Reserves and Threatened Species

Woomargama National Park is located immediately north of the Murray River, which forms the NSW/Victorian border and is approximately 20 kilometres south-east of Holbrook and 30 kilometres north-east of Albury on the South West Slopes of NSW. Woomargama National Park is comprised of just over 24 000 hectares, with warm summers and cool winters and an average annual rainfall of 700 mm.

The main land use in the area is agriculture, including cropping and grazing, and pine forestry. Privately owned pine plantations border the east and west boundaries of Woomargama NP. The reserve protects an area of highly diverse forest and woodland communities on the northern and western extent of an almost continuous belt of vegetation between south-east NSW and northern Victoria. The forests support a suite of native fauna, some of which are at the limit of their western distribution. The reserves are situated in the transition zone between the mountainous NSW South West Slopes and the broader plains of the Riverina.

Significant occurrences of old growth Yellow Box (*Eucalyptus melliodora*), and Blakely's Red Gum (*Eucalyptus blakelyi*) occur in the central western sections of Woomargama NP. These are regarded as a component of the White Box/Yellow Box/Blakely's Red Gum woodland that is listed as an EEC. Other threatened flora include the phantom wattle (*Acacia phasmoides*), a small to medium sized shrub, which is found in the south of the reserve in one specific watercourse where Broad-leaved Peppermint/Norton's Box grassy forest dominates. This is the only known population of this species in NSW and one of only five populations in Australia. Out of a total known number of 405 plants in the wild, the Woomargama population accounts for 320 individuals, or 80% of the known distribution of this species. The small snake orchid (*Diuris pedunculata*) is also found in moist grassy areas in sclerophyll forest within the reserve. Threats to the survival of these species include grazing by goats, pigs and deer and high frequency, high intensity fire (DECCW 2009).

Four threatened mammals are found in Woomargama NP: the koala (*Phascolarctos cinereus*); the yellow-bellied sheath-tail bat (*Saccolaimus flaviventris*); the greater long-eared bat (*Nyctophilus timoriensis*); and, the eastern false pipistrelle (*Falsistrellus tasmaniensis*).

Eighteen threatened birds have been recorded in this reserve including the regent honeyeater (*Xanthomyza phrygia*) and painted snipe (*Rostratula benghalensis australis*). Threats to threatened birds include clearing and fragmentation of forest habitat and loss of hollow bearing trees, predation and grazing or disturbance of wetlands.

5.7.2 SPC Target species

Goats, pigs and rabbits will be the primary targets for SPC in Woomargama NP. These species are listed in the Southern Ranges RPMS as critical threats to the

survival of the phantom wattle and small snake orchid (OEH 2012c). Secondary targets are, but not limited to, deer, wild dogs, foxes and cats.

5.7.3 Vertebrate Pest Monitoring

Vertebrate pests are in very low abundance in Woomargama NP (David Pearce, NPWS Ranger, Riverina-Highlands Area and Peter Scobie, SPC Operations Supervisor, personal communication, 2014) and as such aerial surveys would be unsuitable. Spotlight counts were not considered due to the nature of the reserve (steep and heavily wooded). Sign counts would normally be an appropriate alternative and was trialled (see below). Consequently motion-triggered cameras were selected to monitor pest animal activity throughout the reserve to increase the likelihood of capturing elusive species (Tobler *et al.* 2008). Use of cameras in wildlife management is increasing rapidly and globally and is a very convenient tool for determining site occupancy (Meek *et al.* 2014). Changes in a species activity at camera sites during the trial period will point towards a change in the occupancy of said species (note that only change in occupancy will be indicated by this method). It will be inferred that a reduction in pest animal activity indicates a reduction in occupancy and pest animal population size.

40 cameras will be placed throughout Woomargama NP. 32 will be placed on game trails (located near road ways for practicality). Cameras will be spaced at approximately 1.5km intervals. The remaining 8 cameras will be placed in close proximity to phantom wattle sites. Unlike other camera monitoring for SPC, the camera set up in Woomargama will be active in that a salt block will be used as an attractant. This attractant will increase the chance of obtaining identifiable images of animals that would otherwise be potentially moving swiftly past a camera.

Changes in pest species activity recorded at cameras sites located near phantom wattle will be used to infer a reduction in the impact of pest species on the phantom wattle. It will be assumed that a decrease in the activity of pest species at the phantom wattle location will mean a reduction in browsing/damage and therefore a reduction in the impact of pest species.

Transects recording vertebrate pest sign (e.g. pellets, rubbings, wallows, etc.) were initially trialled as a secondary measure of animal activity. This technique is used in other SPC trial reserves and may have allowed a comparison of pest animal activity between Woomargama NP and these reserves. The continuation of this method was ceased after the trial garnered low confidence data (misinterpretation of some sign and dung). A revised strategy of using cameras in clusters at sites previously identified as having pest animal activity will be used in addition to the active cameras. Clusters will be 4 cameras set in a 100m grid.

Active Cameras

- There will be 40 monitoring sites: 32 spaced approximately 1.5km apart on game trails close to management trails, 8 placed around known phantom wattle sites.
- One Reconyx PC800 Hyperfire camera is securely attached to a suitable tree at each of the sampling points. The set up is such that the camera is not facing the rising or setting sun, at a height of approximately 1m and with a very slight downwards angle.
- Each camera is set for a minimum of 14 consecutive nights. Timing of deployment is autumn and spring each year.
- Cameras are active set: a urea-free salt block is placed in front of the camera to encourage animals to pause. Cameras are programmed to take 3 images per trigger event with a 60 second delay between trigger events.
- After the completion of the minimum deployment time the cameras are retrieved and the images downloaded.
- Images are tagged using ExifPro software for analysis

Passive Cameras

- There will be 10 monitoring sites with 4 cameras placed in a grid formation approximately 100m apart (ie 40 cameras in total). The ten sites were chosen after evaluating the first round of active camera monitoring
- One Reconyx PC800 Hyperfire camera is securely attached to a suitable tree next to a game trail at each of the sampling points. The set up is such that the camera is not facing the rising or setting sun, at a height of approximately 1m and with a very slight downwards angle.
- Each camera is set for a minimum of 14 consecutive nights. Timing of deployment is after the active camera monitoring has been completed each autumn and spring.
- Cameras are passive set: no attractant is used. Cameras are programmed to take 3 images per trigger event with a 60 second delay between trigger events.
- After the completion of the minimum deployment time the cameras are retrieved and the images downloaded.
- Images are tagged using ExifPro software for analysis



Figure 13 Sambar deer captured by motion-triggered cameras in Woomargama NP (SPC).

5.7.4 Threatened Species Monitoring

The phantom wattle has been part of an ongoing volunteer program for the protection and revegetation of the species within Woomargama National Park. This has involved propagation, replanting monitoring and maintenance of this threatened species. Thirty volunteers form the membership of the Woomargama Volunteer Group responsible for the conservation of the phantom wattle, which has been operating since at least 2011. SPC pest animal monitoring activities have discovered a small, new population and a recent survey by the NPWS Biodiversity and Wildlife Team found a new and large population of phantom wattle at the head of Basin Creek (see Figure 14).

Impacts of vertebrate pest on the snake orchid will not be measured. This species is small and difficult to find making direct monitoring unrealistic. Instead changes in impact on the snake orchid will be inferred from changes in vertebrate pest animal activity measured on cameras and transect.

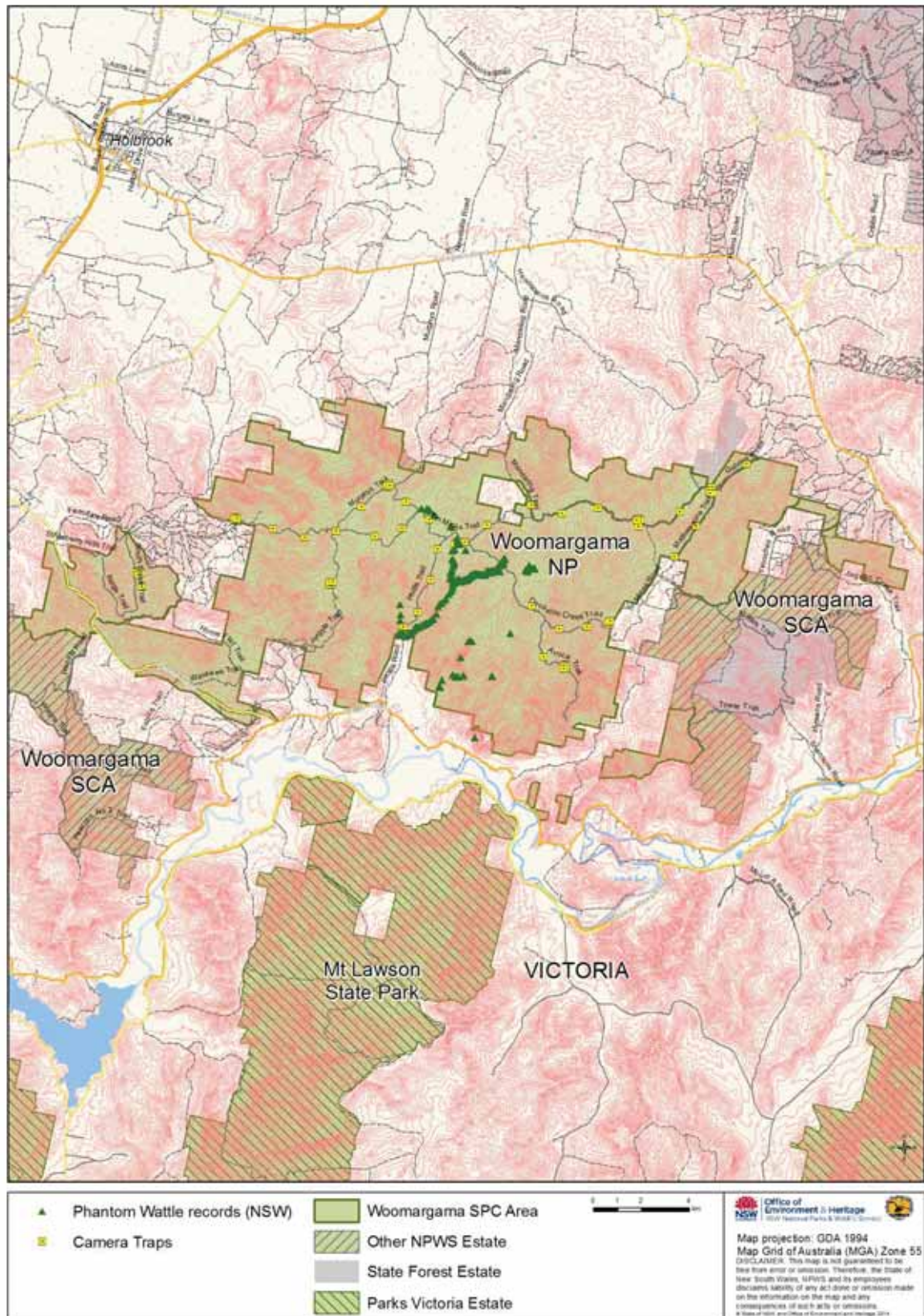


Figure 14 Woomargama National Park showing threatened flora records

6 Operational Monitoring of SPC

6.1 Cost

The amount of effort expended directly for SPC will be evaluated using the existing OEH Asset Maintenance System (AMS). A non-spatial Systems Applications and Products (SAP) System will capture time and cost effectiveness.

Information collated will include: salary (non-overtime), overtime, accommodation and catering, motor vehicles, incidental cost, and work hours.

6.2 Species and number of animals removed

An Environmental Systems Research Institute (ESRI) geodatabase has been developed to accommodate spatial requirements of the SPC trial and will include operational areas and point locations and numbers of animals destroyed. This data will be incorporated into the NPWS Pest and Weed Information System (PWIS).

6.3 Volunteers

The number of volunteers and volunteer hours will be recorded in total and per operation.

As part of the evaluation process the skill and abilities of SPC volunteers will also be recorded in a Volunteer Appraisal form by NPWS Operation Supervisors at the conclusion of each SPC Operation.

The information collected will be used to identify any training requirements, track the skill development of volunteers, and help improve and adapt the program over the course of the trial.

6.4 Safety

Safety is of paramount importance to the SPC trial and will be monitored by the use of two reporting systems.

WorkSafeOnline is OEH's web based WHS system which allows the capture and management of incidents, hazards and workplace audits. This reporting tool will be used for all SPC related accidents and near misses.

SPC Online was developed specifically for the SPC trial and is OEH's web based recording system which allows the capture and management of SPC issues and operation debriefs. This reporting tool collects all complaints and animal welfare, safety and communication issues. These may be reported by the general public, NPWS staff and contractors among others. Operational debriefs are also recorded in SPC online to allow constant improvement of the trial.

6.5 Animal Welfare

NPWS is dedicated to the humane destruction of pest animals in all shooting operations. Animal welfare protocols have been established and every effort is made to adhere to them. Any breaches of these protocols will be recorded in SPC online

via operational debriefs. Members of the general public have the opportunity to report animal welfare incidents or concerns, which may or may not have any connection to SPC, by contacting local NPWS office's or OEH's Environment Line. Information reported this way will be entered into SPC Online.

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