Lake Tyers Deer Management Trial

2019-2021

Victorian Biodiversity Response Program

Gunaikurnai Land and Waters Aboriginal Corporation

GUNAIKURNAI LAND & WATERS

CONSERVATION MANAGEMENT NETWORK

State Government Victoria

Department of Environment, Land, Water & Planning

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Executive summary

Large herbivores are major determinants of plant community composition, structure and dynamics world-wide (Augustine & McNaughton, 1998; Diaz et al., 2007). Deer (family *Cervidae*) including Sambar are amongst the world's most successful invasive mammals, capable of substantial impacts on and major threats to natural ecosystems (Davis et al., 2015).

With funding from the Victorian government's Biodiversity Response Program (BRP), the Department of Environment Land Water and Planning (DELWP) partnered with the East Gippsland Conservation Management Network (EGCMN), Traditional Owners, major public land managers, private landowners and recreational hunting organisations to deliver possibly Victoria's first cross-land tenure, landscape scale deer control project, the Lake Tyers Deer Management Trial.

Between 2019 and 2021 EGCMN and DELWP, with project partners, developed and delivered this coordinated deer control trial by elevating hunting pressure across a ~38000ha project area, centred on the critically endangered Littoral Rainforests of Lake Tyers in East Gippsland, Victoria.

Implementing a Before-After-Control-Impact experimental design, 160 vegetation plots and 80 IR cameras were utilised to evaluate and test the central hypothesis that coordinated hunting as a management intervention, can reduce deer abundance and improve vegetation condition at scale. The project engaged and coordinated over 50 individual recreational hunters, 26 private landowners and 10 partner organisations, to remove over 1000 deer from the project Treatment area.

Unforeseen circumstances, including the corona virus pandemic covid-19, the most significant bushfire event in living memory and the end of a severe drought, presented major challenges to project delivery. Hunter reporting reluctance was also a significant issue.

Camera trap monitoring data showed a greater reduction in deer relative abundance in the Treatment area where hunting pressure was deliberately elevated than in the Reference area where it was not. This suggests coordinated hunting is able to influence deer abundance at

scale. However, as this was a non-statistically significant result, observed changes are not necessarily solely attributable to our management intervention.

Vegetation regeneration declined in areas where coordinated deer control did not occur, but remained constant where hunting pressure was elevated, suggesting deer control is able to stabilise and facilitate vegetation regeneration by reducing deer impacts such as browsing pressure.

Many other results were either non-conclusive, counter intuitive or confounding. For example, the number of juvenile deer increased, along with the deer damage score, where deer control had been undertaken.

We conclude that our hypothesis is partly supported but requires further refinement and testing to provide robust conclusions. We also maintain that the partnership driven cross-tenure approach taken here is the most likely to deliver successful reductions in landscape scale deer impacts and shows long term promise. We also conclude that while the goodwill of the recreational hunting community is not to be discounted, coordination of multiple landowners and hunters comes at significant cost.

Future projects would benefit from better quantifying the overall recreational hunting effort and either an increase in project coordination resourcing and effort or reduction in overall project area to aid quantification of the relationship between the management interventions and response variables.

Introduction

Littoral Rainforests

Littoral Rainforest (Littoral Rainforest) exists as a series of vegetation communities classified as Warm Temperate Rainforest, which are composed predominately of tropically derived species (Peel, 2007). On the east coast of Australia Littoral Rainforest presents as a complex of rainforest and coastal vine thickets, found from the Gippsland Lakes in Victoria at the southern extent of its distribution to Cape York Peninsula in Queensland to the north.

Typically, the ecological community occurs within two kilometres of the coast or adjacent to a large saltwater body, such as an estuary. Littoral Rainforest is distinct from other similar vegetation types (coastal warm temperate rainforest) due to the disproportionate influence

exerted on it by coastal/ocean processes. It is naturally distributed as a series of disjunct and localised stands, occurring on a diverse range of landforms and as a result, the ecological community is not associated with a particular soil type (Threatened Species Scientific Committee, 2008).

FIGURE 1: LITTORAL RAINFOREST, EAST GIPPSLAND. IMAGE T. CROOK

Littoral Rainforest is defined largely by its habitat characteristics, expressed in terms of structure, floristic composition and ecology and the influence of coastal processes, including salt-laden air, saline water tables and occasional inundation brought about by the community's coastal proximity (Threatened Species Scientific Committee, 2008).

Conservation status

'Littoral Rainforest and Coastal Vine Thickets of Eastern Australia' was listed as 'Critically Endangered' under the Environmental Protection Biodiversity Conservation Act (EPBC) in 2008. The 'Critically Endangered' status indicates that the community is at high risk of extinction**.** This is due both to its naturally restricted distribution–and its significantly reduced abundance since European colonisation, primarily due to extensive clearing, coastal development and subsequent weed invasion, recreational disturbance, grazing, fire, exacerbated natural disturbance, climate change and increasingly, animal browsing by exotic herbivores.

Littoral Rainforest provides habitat for over 70 threatened species and provides an important buffer to coastal erosion and wind damage (Department of the Environment and Energy, 2019). The Littoral Rainforest and Coastal Vine Thickets of Eastern Australia ecological community currently has no official conservation status or listing within Victoria. The most

closely related Ecological Vegetation Class (EVC), EVC 4: Coastal Vine-rich Forest, has a bioregional conservation status of 'Vulnerable' within Victoria (Ethos, 2021).

Geographic scope and regional context

Littoral Rainforest in Victoria is entirely confined to East Gippsland, where the known extent of the community occurs from the Nicholson River in the west to Mallacoota Inlet in the east. It exists as scattered clusters of stands along the East Gippsland coast, often forming mosaics, or transitions into other rainforest communities and vegetation types (Keith, 2004).

Within its known Victorian distribution, Littoral Rainforest's main aggregations occur around the Gippsland Lakes, Ewing Morass, the lower Snowy and Brodribb estuaries, Marlo, Cape Conran, areas of the Croajingalong National Park between Wingan Inlet and Mallacoota, the lower Genoa River, and Mallacoota Inlet. The highest concentration of known individual stands are found in the east of its distribution around Lake Tyers.

Prior to the 2019-20 bushfires, the eastern coastline of East Gippsland provided a relatively undisturbed landscape for this highly specialised vegetation community, compared to the western extent of its distribution, where it predominantly occurs close to towns and developed land and was generally found in a more modified and degraded state. Only a small number of Littoral Rainforest stands in East Gippsland are now relatively undisturbed, either through human disturbance or extensive severe wildfire (Ethos, 2021), with most of this now occurring at Lake Tyers.

The impacts of Sambar deer on Littoral Rainforest

Introduced herbivores can prevent the establishment of seedlings, open up the understorey and create gaps in vegetation, facilitate weed invasion and alter community composition and vegetation structure (Taylor et al., 2011).

Introduced deer pose a significant threat to the Littoral Rainforest and Coastal Vine Thickets of Eastern Australia ecological community (Commonwealth of Australia, 2016).

FIGURE 2: YOUNG 'SPIKER' MALE SAMBAR DEER

The impacts of their browsing and rubbing habits, particularly on native vine and canopy species, has been shown to dramatically alter the structure and composition of Littoral Rainforest sites (Ethos NRM, 2014).

FIGURE 3: ANTLER RING-BARKING BY SAMBAR DEER

Deer modify understory vegetation by severely defoliating plants and snapping stems to access new shoots. Deer also ringbark rainforest and other canopy trees, altering light regimes, canopy health and ecosystem function.

Introduced deer act as a vector for pest plants, transporting them into and within existing sites. Localised disturbance from habitual trails and tracks, particularly along steep slopes, and wallows in wetter areas, create areas of ground disturbance, increase the risk to soil erosion and loss, and the potential for the establishment of pest plants within the community.

Tracks, scats, browsing impacts, rubbing causing tree mortality and wallows have all been observed. From available data, and information from local sources, it is likely the majority of this damage has been caused by the presence or use of rainforest sites by Sambar deer, *Cervus unicolor*, (Ethos, 2021).

FIGURE 4: DEER WALLOW AND RESULTANT SOIL DISTURBANCE

The proportion of sites impacted by introduced deer has increased from approximately 55% in 2013 (Ethos NRM, 2014) to over 75% recorded in this assessment.

Anecdotal evidence (Crook, 2021) suggests that, in Littoral Rainforest stands east of Lake Bunga, deer have become a greater threat than weed invasion.

Previous control work in Littoral Rainforest

Littoral Rainforest has had significant investment through federal and state sources over the last 10 years (>$750,000).

This funding has delivered extent and threat mapping across all known Littoral Rainforest sites in Victoria, weed control works at over 50% of known sites and significant work developing stand condition assessment tools.

FIGURE 5: SAMBAR DEER IN EAST GIPPSLAND

DELWP, along with key partners including the East Gippsland Rainforest Conservation Management Network (EGRCMN), Traditional Owner groups, Trust for Nature (TFN) and Parks Victoria (PV) have undertaken the significant task of mapping the extent of Littoral Rainforest stands, weed occurrences and pest animal

threats. These groups have engaged many members of the East Gippsland community in the protection and rehabilitation of this asset (Ethos, 2021).

FIGURE 6: SAMBAR DEER DAMAGE

Significant participation by Traditional Owners has occurred, with both GLaWAC and Moogji Aboriginal Council undertaking site remediation and monitoring activities. GLaWAC's 'Whole of Country Plan' and the 'Lake Tyers Management Plan' (2018) articulates Traditional Owner aspirations to care for Country, including the active control of deer to protect impacts on rainforests and other cultural values.

There has also been some Victorian state investment through grants from Coastcare and Landcare with significant community engagement utilised to revegetate Littoral Rainforest stands.

The Threatened Species Protection Initiative funded DELWP and EGRCMN to construct deer exclusion fences, develop preliminary methods to assess deer occupancy rates and changes in stand vegetation structure and composition.

FIGURE 7: SAMBAR DEER SOIL DISTURBANCE L & PATHWAY R

A survey of local residents about the presence and impacts associated with Sambar deer was conducted by EGRCMN in 2017. A majority of the 208 respondents reported having experienced some 'negative impacts' from Sambar deer and feeling that 'some control' was warranted. Locals reported deer as a driver of native vegetation condition decline, especially rainforests, and negative impacts on agricultural production via direct competition with domestic stock for pasture resources, damage to farm infrastructure such as fences, waterpoints and animal health. Road safety was also an area of growing concern.

A deer forum, organised by EGRCMN was held in Bairnsdale with major stakeholders in 2018, with over 100 attendees. It was largely agreed that a pathway to effective deer population management was required and a coordinated control trial warranted.

Project aims, rationale and scope

The aim of the Lake Tyers Deer Management Trial (the project) was to develop and deliver a partnership-based deer control trial to reduce deer relative abundance and evaluate the effectiveness of coordinated hunting as a management intervention to improve Littoral Rainforest condition.

The project also aimed to provide a foundation to assist on-going management of deer impacts at a landscape scale by bringing private landholders, Traditional Owners, public land managers and community groups together to build partnerships and a common understanding of the need for and methods to deliver deer control.

It was understood by project designers that "shooting can be a humane method of removing feral deer when it is carried out by experienced, skilled shooters; the animal can be clearly seen and is within range; and, the correct firearm, ammunition and shot placement is used." (Sharp, 2012).

The purpose of the Lake Tyers Deer Management Trial was to deliver deer control across public and private land in the Lake Tyers area, to lessen deer impacts. The aim was to identify, test and monitor land management practices that support effective deer management in the Lake Tyers area.

An additional focus of the project was establishing control methods on private property, where resources are more concentrated (pasture, water) and deer are known to congregate. Landowners and public land managers were linked with skilled registered hunters to undertake deer management activities in a coordinated, regulated and systematic way.

FIGURE 8: UNDERSTORY VEGETATION MODIFIED BY SAMBAR DEER, LAKE TYERS

The project aided with administrative processes that directed recreational and other hunting efforts to target deer around high conservation value areas. The aim was to better integrate the goodwill of the hunting community and maximise the potential effectiveness of their contribution toward coordinated landscape level deer population control.

The project trial involved key stakeholder groups from Gurnaikurnai Land and Waters Aboriginal Corporation (GLaWAC), DELWP, landowners, Parks Victoria, Landcare, VicForests, the Game Management Authority (GMA) and recreational hunting groups, including the Australian Deer Association (ADA) and the Sporting Shooters Association of Australia (SSAA).

Common understandings across stakeholder groups:

- Deer cause negative impacts to crops, soils, native vegetation (including threatened species), water quality–and are a known disease vector. Deer deplete and degrade the aesthetic values of the natural environment. Deer cause vehicle collisions.
- Very little has been tried to manage deer, apart from sporadic hunting on farms and in state forest, with some isolated 'asset based' protection undertaken on private land and within the Parks estate. To date, deer control activities have not occurred in a coordinated way across all land tenures.
- Minimal management and control actions have been previously undertaken within the trial area. Currently around 1/3 of the project area is open to recreational hunting but

this has not been done in a coordinated way. There has been no monitoring to evaluate effort or outcomes–and deer impacts continue to rise.

- Deer currently have no biological control. Control measures need to be trialled. The multi-tenure approach taken by this trial project, is the only option existing currently to reduce deer impacts.
- Carcass removal is a major concern to locals. (The trial encouraged the use of deer related products including the meat, hide and antlers to the greatest extent possible. Where carcass removal was not possible, burial facilities were established with best practise guidelines followed.)
- No single person or group can manage the threats posed by deer. This inherently requires coordinated action between land managers, land tenures and stakeholders.
- Deer are a complex land management issue that requires complex solutions.

Project location - Lake Tyers

The *Gunaikurnai Whole of Country Plan* developed by Gunaikurnai Land and Waters Aboriginal Corporation (GLaWAC) in 2015 sets out the management priorities for Lake Tyers State Park. Lake Tyers is located on the Country of the Krauatungalung clan. As part of a Regional Settlement Agreement, Lake Tyers State Park was granted to the Gunaikurnai people as part of Aboriginal Title by the Victorian government. The Park is now managed under a Joint Management Agreement by Gunaikurnai Traditional Owners, with the Victorian government under the National Parks Act.

Lake Tyers State Park is 10072 ha in size, or 25% of the total project area. The Park consists of densely forested, undulating country that surrounds two tidal estuaries, the Toorloo Arm and the Nowa Nowa Arm, as well as a narrow spit of land between the Lake and Bass Strait. The Park borders substantial areas of private land on the western side of the Nowa Nowa Arm, including the Lake Tyers Aboriginal Reserve which is owned by the Lake Tyers Aboriginal Trust. The western and eastern boundaries of the Park border state forest.

The Park estate holds a majority of the rainforests which occur in the Lake Tyers area and continues to provide an abundance of suitable habitat for Sambar deer, whose presence and impacts have become increasingly evident in recent years.

Historically, little coordinated deer control has been undertaken within the Park extent. Several attempts have previously been made to control deer numbers in the south-east section of the Park around Trident Arm, to protect rainforest values (TFN, 2018) but operational constraints rendered these attempts largely ineffective.

While evidence suggests the Park is hunted illegally, this appears to be largely confined to the road network and occurs sporadically. The extent of this activity is understood to have had no material effect on deer numbers.

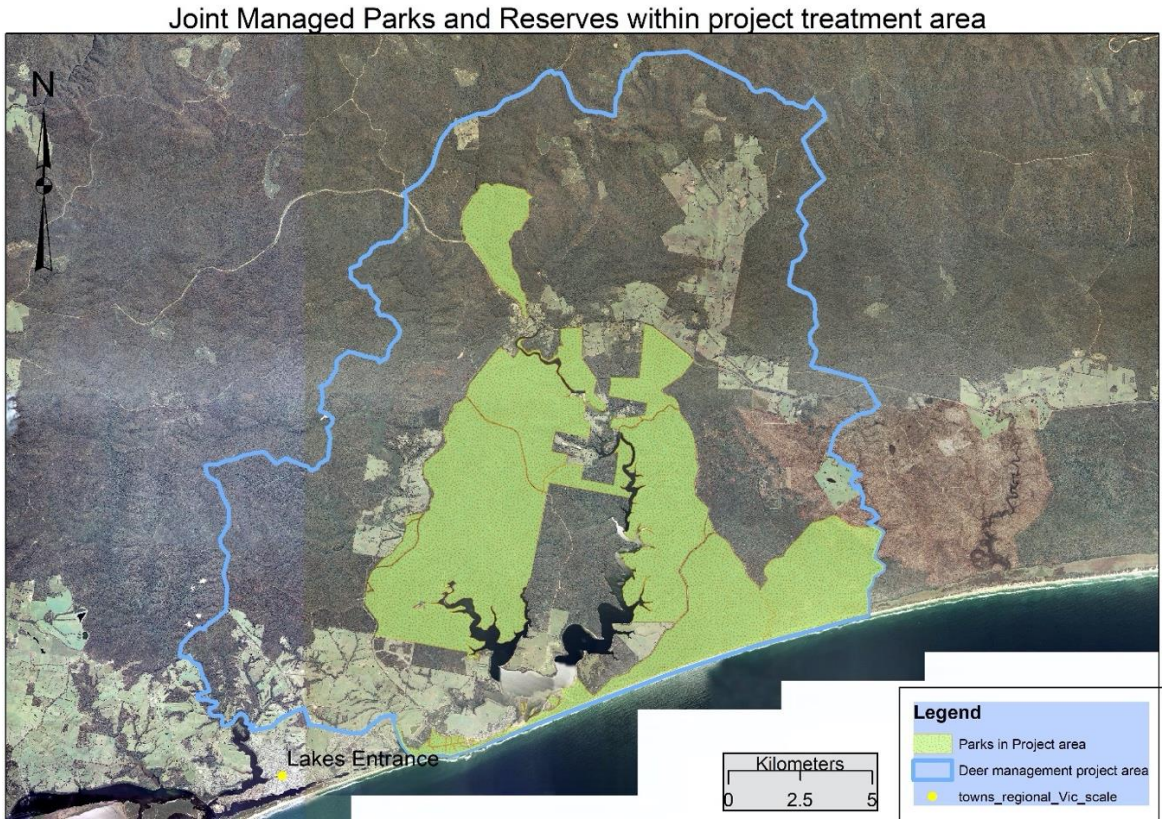


FIGURE 9: JOINT MANAGED PARK AND BROADER PROJECT AREA AT LAKE TYERS

A Partnership based approach

This project deliberately brought together various groups and stakeholders from across the ideological spectrum. This was an attempt to work more effectively to evaluate and provide solutions to the increasing problem of introduced deer. Natural resources and environmental values are often viewed differently by various stakeholders. It was the firm belief of project managers that a cooperative approach to land management would provide the best possible opportunity to deliver effective long-term solutions.

Key Stakeholders engagement and involvement

Key stakeholders identified, approached and involved in the project include: Traditional Owner group, the Gunaikurnai Land and Waters Aboriginal Corporation (GLaWAC), government land management agencies, in particular Parks Victoria, local community environment groups including the region's two Landcare Networks and several area-based Landcare groups, peak recreational hunting organisations the Australian Deer Association (ADA) and Victorian Sporting Shooters Association Australia (SSAA), private landowners within the project area and individual volunteers willing to participate in the project.

Traditional Owners

The project area is subject to Native Title determination of the areas as the lands of the GunaiKurnai Traditional Owners, who control the region's only 'Registered Aboriginal Party', (GLaWAC).

Input from GLaWAC was sought during the project's development. This partnership had been actively cultivated through delivery of various projects with EGCMN over several years.

GLaWAC has consistently expressed concern around the impacts on vegetation and other values caused by deer. GLaWAC participated in various deer monitoring activities, mainly facilitated by the EGCMN, from around 2015.

FIGURE 10: GUNAIKURNAI ON-COUNTRY TEAM

EGCMN engaged with GLaWAC to develop an understanding of how cultural values are impacted by deer, local Custodians' interactions and processes in relation to deer impacts, and prevailing First Nations attitudes toward introduced deer and their management.

In this project GLaWAC's main role was as a land manager. GLaWAC actively participated in the impacts assessments and monitoring activities delivered by the project over several years.

Moogji Aboriginal Council also played an important role throughout the project. As well as providing land manager consent they informed the project on how deer were impacting on cultural values, reinforcing the need for control measures.

Both groups played a key role in camera monitoring deployment which aided in building capacity within their organisations to plan, deliver and be an active part in future deer control. See appendix A- Joint Management Ranger Report on Sambar Deer in Lake Tyers State Park.

Recreational hunting organisations

Recreational hunting organisations were approached via their respective national and state coordinators. Several meetings were held, including with local branch members to establish their capacity to assist with ongoing project delivery.

Australian Deer Association

The Australian Deer Association (ADA) formed an important part of this partnership driven project. ADA proved willing to provide advice–and liaise with and organise hunters. ADA has been actively involved in deer management over many years, having participated in various deer control activities lead by Parks Victoria in the Wilsons's Promontory and Alpine National Parks, amongst others.

Contact was initially made with the organisation via their national executive, which made suggestions on the nature of communications with hunters. ADA then facilitated contact with their local East Gippsland branch.

The project team presented to an East Gippsland ADA committee meeting early in 2019, to discuss their potential involvement and support, which was subsequently forthcoming and has been on-going.

ADA's East Gippsland branch have a long-standing commitment to assisting with 'conservation hunting' and was a key partner in the formation of the 'Deer Management Group' (DMG) established by the East Gippsland Rainforest Conservation Management Network and Trust For Nature in the mid-2000's. ADA, as well as providing links with local hunters, greatly assisted the program by providing an avenue for hunter accreditation (see below).

The main aims of the Deer Management Group (Mills, pers comms, 2018):

- Legally and ethically cull deer in order to protect biodiversity assets. Deer removal is aimed at a level that reduces the impact and reverses deer damage to reinstate ecological function and processes – allowing the vegetation quality to return to its former condition.
- Create a trustworthy and highly skilled group that can operate on Trust for Nature covenants as required.
- Break down barriers between historically opposed groups, perceived and real (hunters & conservationists).

Sporting Shooters Association Australia

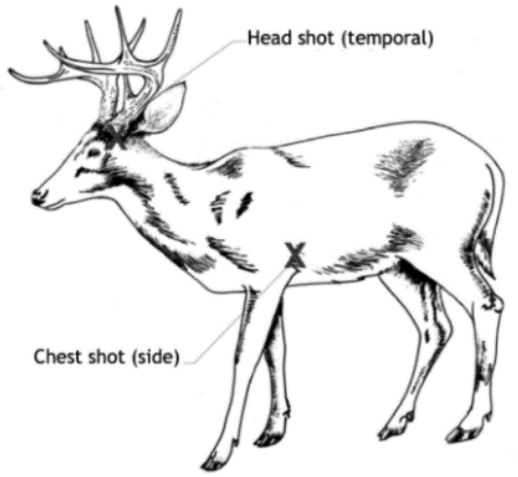
SSAA has been actively engaged in the pest and problem animal space for many years, having successfully delivered pest control programs in collaboration with state government agencies in Victorian and South Australian National Parks. In 2007 SSAA Victoria signed a Memorandum of Understanding with Parks Victoria (the Conservation and Pest Management Program) to assist with the management of pest animals on state-owned land.

SSAA also have a long-standing control program called 'Farmer assist' whereby hunters who have gained accreditation are paired with landowners/farmers requiring assistance with pest or problem species.

Within the SSAA, Conservation & Wildlife Management (CWM) branches aim to assist in the conservation of native animals and the management or eradication of feral species in a coordinated manner.

In order to participate in CWM branches, certain skills must be demonstrated. An accreditation program consists of map reading, navigation, firearm safety and handling, shooting accuracy, wildlife appreciation and management, living in the field and ethical hunting. First-aid courses must also be passed.

Accreditation



The facilitation of pest control works involving volunteer hunters and private landowners can be challenging, with landowners often reluctant to allow hunters, who they often don't know, onto their land to hunt with high powered firearms.

In order to provide a level of assurance to landowners, where access to private land was involved, only accredited hunters were allowed to participate in the project. This ensured benefits such as insurance for participating hunters and, to the greatest extent possible, that hunting was conducted in an ethical and safe manner.

ADA and SSAA proved to be invaluable to the project. They were able to coordinate the accreditation process for hunters. They provided standard operating procedures and assisted with the implementation of hunting activities. An agreed framework for hunting activities meant increased hunting safety and aided in community confidence in, and understanding of hunter professionalism.

Other standard operating procedures were also utilised to ensure safe and ethical hunting, such as Trudy Sharp's, 2012 Ground shooting of feral deer, Standard Operating Procedure.

Community engagement

A communications plan was developed and used to guide public outreach. Multiple media representations were made in local newspapers (Bairnsdale Advertiser, Lakes Post and Snowy River Mail) and on local radio and regional television. The project was detailed and discussed, including the need and rationale for deer control and requests for hunters to participate in the project and 'be a part of the solution'.

The Far East Victorian Landcare Network (FEVL) based in Orbost, was engaged and funded to assist with local outreach activities. The Wairewa community was identified in the project's first hunting season as a good place to commence control activities due to the community

experiencing a range of negative impacts from deer and having expressed a willingness to be 'doing something' about the problem.

Community organisations such as FEVL were utilised in the early stages of the project to facilitate engagement with land-owners known to be experiencing problems with deer.

These community meetings proved highly valuable in providing an entry point into the project. The forums explained the overall project rationale, answered community questions and allowed landowners to 'sign up'.

FIGURE 11: COMMUNITY PLANNING MEETING IN WAIREWA, 2019

During community meetings, large format printed maps were used to share information about landowners' views and enable open conversations about what could occur, including opportunities for collaboration and coordination of control activities between properties.

Community hall meetings and barbeques also proved useful as a mechanism to demystify some of the control techniques employed by experienced hunters, such as the use of hounds/dogs. Hunters and their dogs were able to meet with community members who were open to deer control, but concerned about some of the techniques available. Community concerns were effectively allayed.

A cross land tenure approach

It is now commonly recognised that pest control activities, for example fox management, need to operate on 'both sides of the fence' if they are to be effective. A cross land tenure approach formed a central tenet of this project's work.

Private land deer control

Almost 9000 hectares of private land occurs within the project Treatment area (23%) and was concentrated in the central and eastern sections of the overall site (see Fig. 10 below).

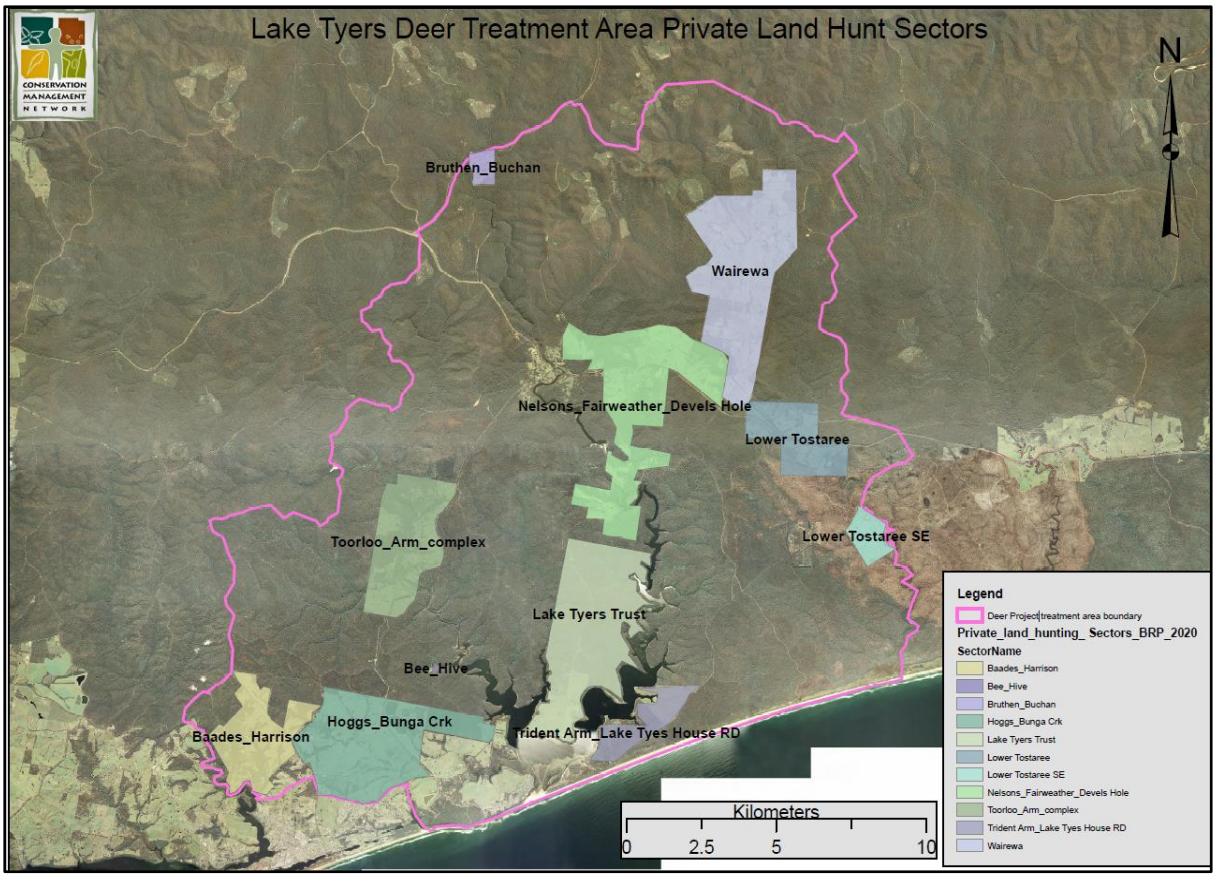


FIGURE 12: PRIVATE LAND WITHIN THE DEER CONTROL TARGET AREA

Private land was central to this multi-tenure project and presented both challenges and opportunities for deer control, relative to other land tenures.

Unlike the public land estate, each parcel of private land is subject to an individual set of circumstances–activities able to occur on private land are ultimately controlled by the will of individual landowners. Approaches to landowners and negotiations around project involvement were found to be time consuming and demanding in terms of resourcing and later coordination.

Landowner mailout

In 2020 a mailout to all private land address points within the project area was conducted, in order to solicit project involvement from private landowners (see Appendix B).

A total of 45 responses were received from around 300 letters sent (15%). Each responding landowner was subsequently contacted by phone or email to arrange a discussion about engagement with the project and provided with project information sheets (See Appendix C).

Landowner responses and willingness to participate varied widely. Responses ranged from landowners already conducting their own deer control activities and not requiring assistance, to those requesting assistance and seeking additional help to manage deer impacts on their land.

Landowners conducting their own control activities were asked to provide estimates of the time taken conducting control activities and any return for their efforts (numbers of deer and time taken). They were provided with datasheets and other means to do so.

Landowners requesting deer control assistance or a willingness to participate in the project were introduced to hunters from either ADA or SSAA, with an initial site inspection and introductory meeting arranged.

Several properties were, upon inspection with hunters, found to be impractical or deemed to be unsafe to proceed with deer control activities. This was due to the topography of the property or commonly, proximity to neighbours.

Commercial utilisation of the deer 'resource'

New regulations now permit 'commercial harvest' and sale of deer meat from private (and public) land. Commercial deer operations are able to assist in reducing deer numbers/impacts by paying private landowners by the kilo for deer removed from their land.

A partnership was developed with several commercial operators to explore the potential of commercial harvest of introduced shot deer on private land and the public/private interface. These kinds of partnerships have anecdotally been successful in other areas (Bindi Station for example) at reducing deer numbers and their associated impacts on agricultural production.

Various attempts were made to deploy commercial hunting activities within the project area, to complement and aid control efforts. Unfortunately, these activities were limited in their deployment due to Covid-19 restrictions, changes in market forces and state regulation, preventing them from being used to any significant extent.

State forest hunting

The areas of state forest within the project footprint comprise around 17,000 HA or around 40% of the total (see Figure 13). Hunting is already largely permitted, with some level of recreational hunting known to occur. These areas were divided into 'hunt sectors' (See Figure 14) in order to coordinate the hunting effort and provide a mechanism to ensure hunters were spatially separated to the greatest extent possible as a safety precaution.

A calendar was used to keep track of hunters' location and intended times of operation. This proved effective initially, but later lost utility as hunting became more sporadic and dispersed as Covid-19 restrictions came into force and intensified.

The spatial dataset 'Hunt25' was used by the project to provide detailed information to existing and prospective hunters as to which sections of the landscape within the broader project area were 'open' for hunting (See Figure 13 below).

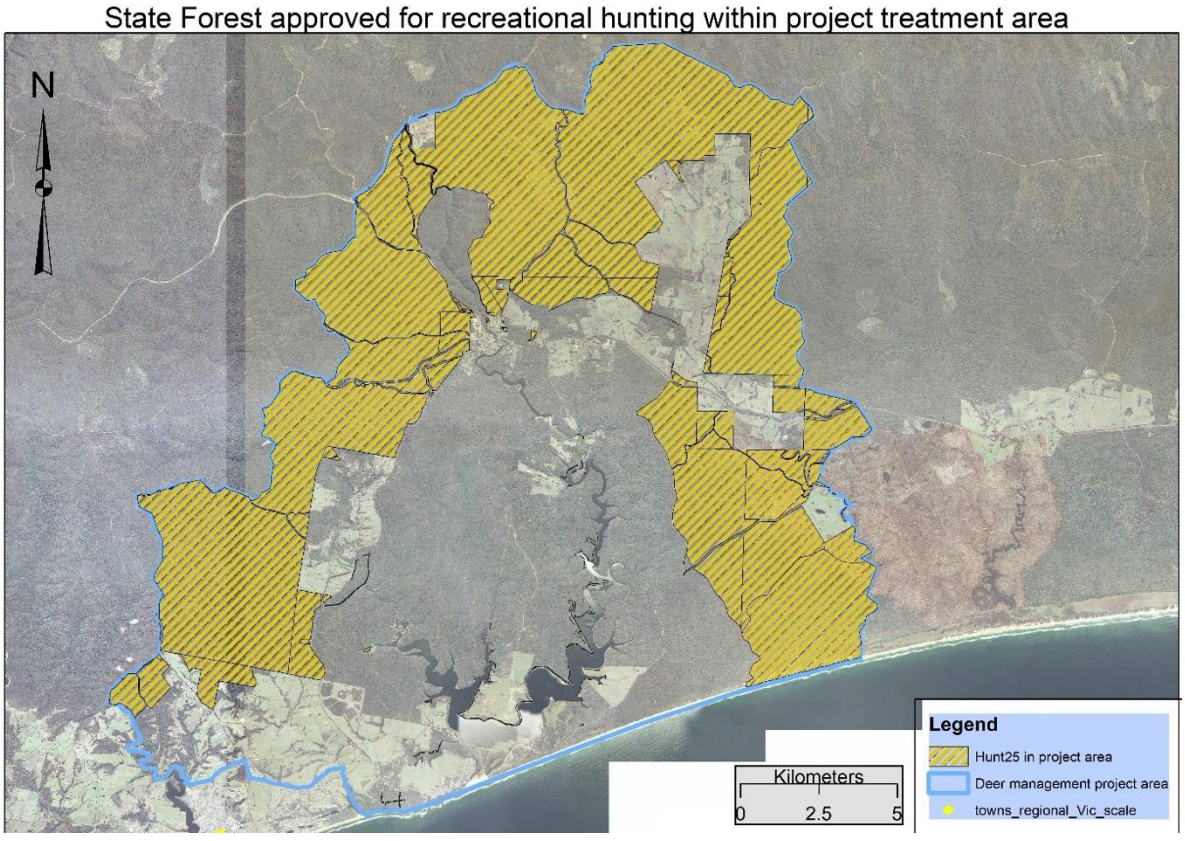


FIGURE 13: STATE FOREST APPROVED FOR DEER HUNTING

The provision of this 'hunting layer' within the state government 'More to Explore' mobile phone application was also promoted to hunters as a way to ensure areas being hunted were both legal and permitted.

Hunting in state forest within the project area was promoted throughout the duration of the project. Around 100 individual hunters made contact with project staff and expressed a willingness to be involved. Many of these people were provided with additional information on project aims, and ways they could participate. Around half (50) subsequently received detailed information to increase hunting success. This included maps tailored to their specific area of interest, and deer presence data arising from our monitoring activities.

All hunters wishing to participate in hunting state forest areas as part of the project were provided with data sheets to report any hunting activity undertaken within the project area.

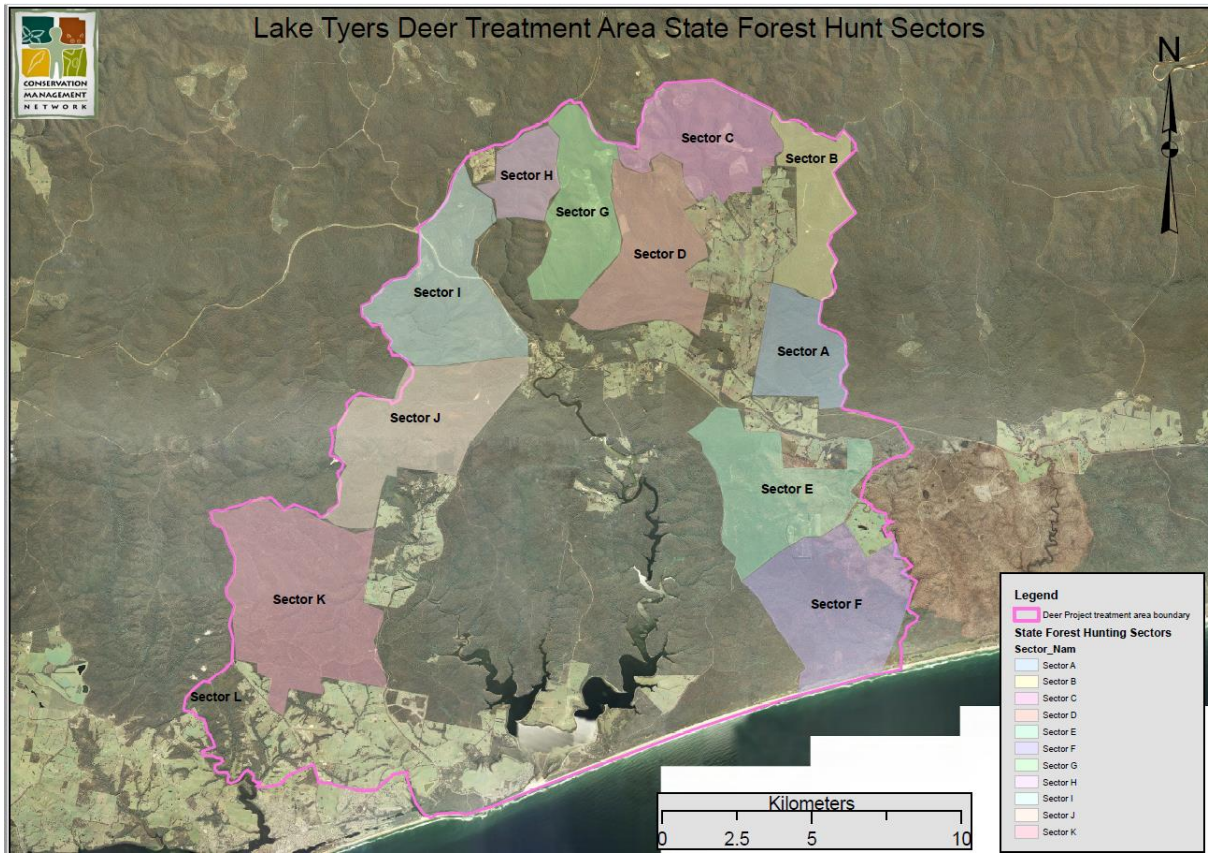


FIGURE 14: THE PROJECT CONTROL AREA'S 'HUNT SECTORS'

Several areas of state forest were also targeted by SSAA and ADA members, using a variety of hunting methods throughout the duration of the project.

Significantly, state forest areas are open to industrial forestry activities which alter forest structure in a way that facilitates hunting in the short term (several years). VicForests, the state-owned logging agency, was contacted in relation to deer damage in areas recently subject to forestry activity. These areas were identified using data download from the Victorian Government's '[Spatial Datamart Victoria]' in the form of logging history layer

(LASTLOG25). This spatial information on areas recently logged, was then 'clipped' using ARCGIS to the project area and used to create maps. These maps were provided to interested hunters as a way to elevate hunting success.

Hunting in the State Park

The Lake Tyers joint managed state park comprises around one third or 10,000HA of the overall project Treatment area (Fig 13).

The project team met Traditional Owner and Parks Victoria representatives early on in the project and negotiated 'in principle agreement' to facilitate hunting operations within the Lake Tyers Joint Managed Parks Estate (see Figure 15). This is an area where deer hunting is otherwise not allowed.

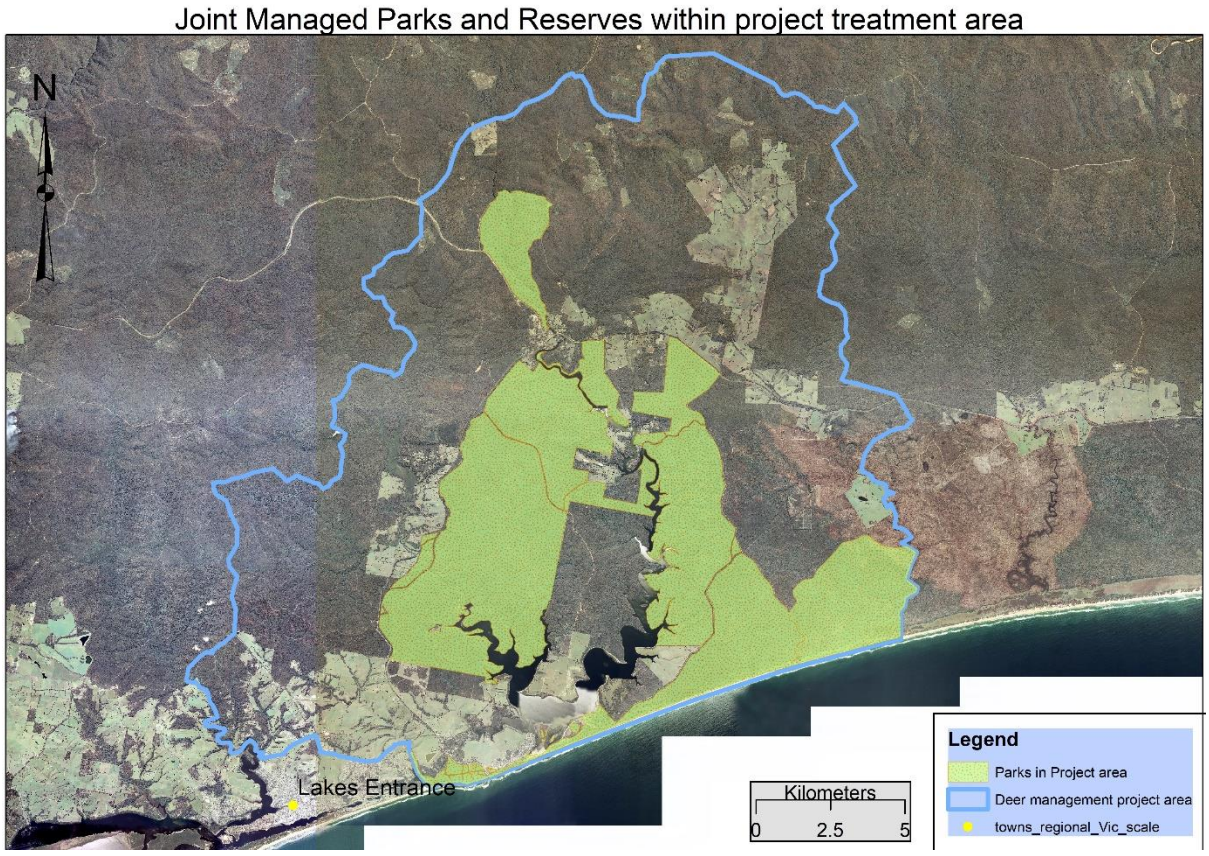


FIGURE 15: JOINT MANAGED PARK WITHIN THE PROJECT TREATMENT AREA

Monitoring

A monitoring protocol was initially developed in consultation with deer research specialists in 2018. This protocol was further refined at project inception to meet project requirements to provide initial baseline data in the project's first year for deer relative abundance and vegetation condition. Variables were later re-monitored in the project's final year to evaluate change.

The following provides a summary of the monitoring rationale and methods used, with text and references* taken directly from Davis, 2018. A full description and rationale (methods, equipment lists and field protocol etc.) is provided as Appendix D to this report.

Monitoring considerations

The selection of an appropriate experimental approach to assess the effectiveness of deer control in reducing deer impacts was influenced by the following considerations:

1. There are limited areas in the region with similar vegetation types and condition, landscape attributes and levels of disturbance that are spatially independent and can be used as a Reference area.
2. Ground-shooting commenced in autumn 2019, with funding approval.
3. Resources available for monitoring were limited.

Management contrasts: before-after/control-impact design

The effectiveness of management interventions can be assessed when different interventions are compared (Lindenmayer and Likens 2010*). Given Consideration 3, a manipulative experimental approach could not be implemented. Therefore, a comparative approach was used: comparison of vegetation between a location where deer were controlled using ground-shooting (Treatment site) with a location where deer were not controlled (Reference site) (see Figure 16, below).

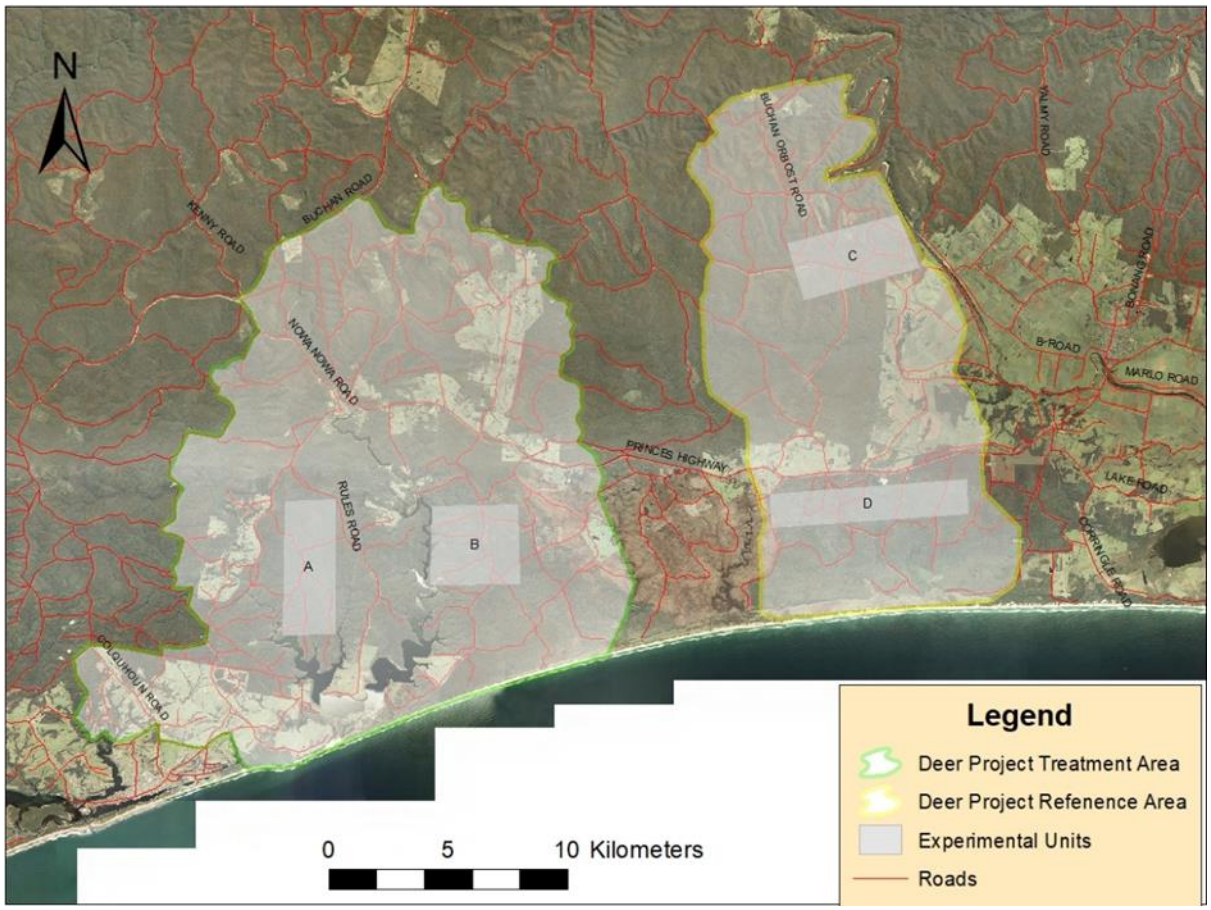


FIGURE 16: EXPERIMENTAL SITES AND SAMPLING UNITS

The design provided a framework to test for deer impacts on vegetation and assess the potential for ground-shooting to reduce impacts and allow vegetation recovery, either through a reduction in the deer population or behavioural responses to shooting (Bennett et al., 2015b).

Given considerations 1 and 3, there was only one Treatment and one Reference site. Two experimental sampling units were nested within each of these sites (Figure 16). This design provided within-site spatial replication. Restriction of the spatial spread of sampling to the experimental sampling units, rather than across each site, ensured that the project was logistically feasible.

Given Consideration 2, it was possible to collect data 'before' deer control. Therefore, a before-after/control-impact design was used. This design was intended to quantify effects of deer control through comparison of response variables measured at a 'Treatment site', with measurements from an unmanipulated 'Reference site', before and after commencement of deer control (Morrison et al., 2008).

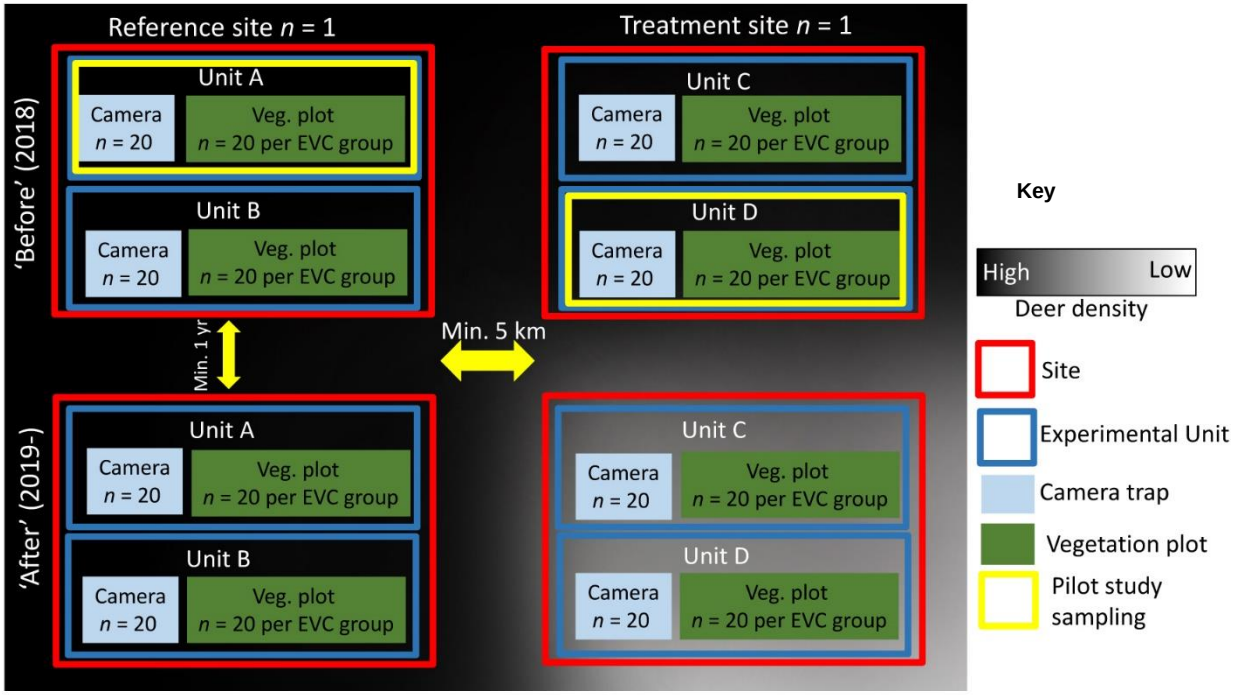


FIGURE 17: DIAGRAM OF EXPERIMENTAL DESIGN

The above diagram of experimental design shows comparisons of data collected using vegetation plots and camera traps between sites subjected to contrasting management interventions (one Treatment site with ground-shooting for deer control, and one Reference site with no ground-shooting for deer control). These sites were predicted to result in a contrast in the relative abundance of deer. Sampling was conducted in two replicate experimental sampling units at each site: with camera sampling spatially randomised across each experimental sampling unit and subsequent years of monitoring constituting 'after' sampling.

Site selection and allocation of Treatments

The lack of replication at the site scale reduces confidence in separating Treatment effects from confounding factors unrelated to deer control (Morrison et al., 2008). Therefore, it is important to match the Reference site to the Treatment site to reduce variability between the sites (Morrison et al., 2008). Specifically, it was recommended that the Reference and Treatment sites that constitute the study area would:

1. be of similar size;

2. have similar vegetation (types and condition) and landscape features (in particular, hydrology, given relatively high deer densities observed in riparian zones in the study area);
3. have similar deer densities and levels of deer impact; and
4. have similar land tenure and level of disturbance.
    a. Recreational hunting occurs throughout the Lake Tyers area where permissible. Ewing Morass Wildlife Reserve is a game reserve and excluded from the study area because hunting patterns differ from the surrounding areas; hog deer hunting levels are relatively great, whereas Sambar hunting is not allowed. Recreational hunting levels are elevated in the 'Beehive' area compared to other parts of the Lake Tyers area, hence this area was excluded from the Treatment and Reference sites.
    b. There is little difference in the management of the State Park and Conservation Recreation Zones, so both were sampled.
    c. The tenure of surrounding land was also important. Similar representation of farmland with respect to area and perimeter was important, as deer had been observed in relatively high densities on farmland-forest ecotones, and farmers in the area may not have allowed recreational hunting but did undertake deer control on their properties.
    d. Fire history in the area is variable and was considered, in particular, a wildfire covering ~1000 ha occurred at Tosteree in 2014.

Importantly the Treatment and Reference sites are spatially independent, so that the abundance and impacts of deer at the Reference were not influenced by ground-shooting at the Treatment site. Information on Sambar deer home range sizes in Australia is lacking, but information for other deer species in other locations suggests that home ranges are generally >50 ha, and commonly hundreds of hectares in size (Nugent 1994, Moriarty 2004, Spaggiari and de Garine-Wichatitsky 2006, Odden and Wegge 2007, Amos et al., 2014, Davis, 2018).

Observations by local land managers suggested that deer in the Lake Tyers area move many kilometres when food is scarce (B. Mills, Trust for Nature 2018, *pers. comm*.). In the Alpine National Park deer control trial, experimental sampling units were separated by only 2 km in places, although deer movement may be hindered by steep terrain in that environment (Davis et al., 2015). Ideally, experimental sampling units are separated by much greater distances (e.g., >10 km; Simard et al., 2013), with a potential trade-off between achieving spatial independence and ensuring site attributes are similar.

Two landscape-scale (>10,000 ha) sites were selected in the vicinity of Lake Tyers. One is the broader area surrounding Lake Tyers (c. 38,918 ha) and the other is to the east of Lake Tyers (c. 20,231 ha) (See Figure 17).

Nested within each of the two landscape-scale sites are two experimental sampling units (i.e., four 'Units' in total). At the Treatment site, Unit A (1,246HA) is located in the West of the site, and Unit B (1,256 ha) is located in the South East of the site (Figure 2). Unit C (1,237 ha) is in the North East of the Reference site and Unit D (1,251HA) is in the South of the Reference site (See Figure 17).

The two sites are separated by a minimum of 5.5 km. These two sites were considered the best match available with respect to criteria 1–4. Both contain large areas of public land in which sampling could be focussed, with similar landscape and vegetation attributes. Although the site to the east is smaller and has considerably less rainforest, both sites are large enough to examine landscape-scale changes and impacts within rainforest and other vegetation communities.

The deer density at the Treatment and Reference sites was unknown, but thought to be similar. The broader area surrounding Lake Tyers was subjectively allocated as the Treatment site because it contains a high proportion of Littoral Rainforest, the focal asset. Further, it is under joint management with the GLaWAC, an important stakeholder. The site to the east of Lake Tyers was therefore allocated to be the Reference site.

Experimental sampling units were selected that contain rainforest (an important vegetation type for sampling) whilst representing the best available matches with respect to criteria 1–4. Experimental sampling units each fall within public land, have similar landscape and vegetation attributes, are of similar size and are thought to have similar deer densities. All Units are in close proximity (<1 km) to private land and dominated by Lowland Forest. While the EVC composition varies slightly among experimental sampling units, the EVCs present are thought to be functionally equivalent. For example, Unit C does not contain Limestone Box Forest, but contains significant areas of Shrubby Dry Forest, which is absent from the other units but thought to be functionally equivalent to Lowland Forest in terms of deer utilisation.

Unit A has a relatively greater area of Damp Forest compared to Unit B, which has a relatively greater area of Limestone Box Forest. A notable difference between the experimental sampling units is that those in the Reference area are in close proximity to a major source of fresh water (the Snowy River in Unit C and Wombat Creek, c. 1 km from Unit D), whereas those in the Treatment area are in close proximity to an estuarine system.

All four experimental sampling units have similar road networks throughout, but Unit A is within 1 km of Princes Highway at its closest point.

Shooting Treatment

FIGURE 18: GLAWAC STAFF DISCUSS DEER IMPACT MONITORING AT LAKE TYERS

The Treatment and Reference sites were largely subject to contrasting deer management interventions. Ground-shooting aimed at reducing deer abundance was conducted across the entire Treatment site as part of the project, but not at the Reference site. Ground-shooting was mainly conducted by volunteer recreational hunters, facilitated by EGCMN, in partnership with the Australian Deer Association and Sporting Shooters. The frequency, intensity, commencement and duration of shooting was not predetermined. Shooting was undertaken throughout winter, commencing around the Easter long weekend and continuing until mid-November – corresponding with the cooler period of the year.

A background level of recreational hunting was known to occur at both the Treatment and Reference sites at similar levels and therefore was not thought to compromise the experimental design. To implement a management contrast, the Lake Tyers project aimed to reduce deer abundance substantially more than uncoordinated recreational hunting does.

Spatial sampling distribution

The aim of the project was to document landscape-scale responses of deer to management intervention. There was good reason to presuppose that Sambar were likely to occupy particular habitat types within the study area (Gormley et al., 2011). When this is the case, the precision of occupancy estimates can be improved by using a stratified random sampling approach that ensures adequate representation of vegetation types in the sample (Nelson and Scroggie, 2009). However, resources available were inadequate to robustly quantify deer occupancy or relative abundance within specific different vegetation types. Therefore, a randomised sampling approach (i.e., without stratification) across each experimental sampling unit was used to document landscape-scale responses of deer to management intervention, modified from Davis et al., (2015):

1. The Treatment and Reference sites were divided into grid cells (Jacobson et al., 1997, Allen et al., 2015), within which no more than one camera was placed in each, to ensure the sampling was spread across the landscape. Camera traps were placed randomly within each grid cell. Tobler and Powell (2013) recommend that the survey area covered by camera traps should be at least the area of one home range, with camera traps spaced less than one home range radius apart. Home range sizes of Sambar in the Lake Tyers area were unknown. Based on the size of the smallest experimental unit (Unit C: Table 1), a cell size of 61. 89 ha (786.71 m × 786. 71 m) was used to fit a sample of 20 cameras. International estimates of female Sambar deer home ranges (c. 2 km^2; Lewis et al., 1990, Fraser and Nugent 2005) suggest that these grid cells would ensure appropriate sampling coverage and camera separation.
2. Sampling locations were separated by ≥ 100 m, so that the likelihood of detecting the same animal at adjacent sites was negligible, or at least that detecting the target species at one site had no effect on the likelihood that it would be detected at other sites (Nelson and Scroggie, 2009).
3. There is an extensive track network in the area providing good access (generally < 400 m walk) to all areas of vegetation in the experimental sampling units. Nonetheless, samples were restricted to < 400 m from a road or track to ensure that sampling was efficient. In addition, cameras were positioned > 10 m from a road or track to reduce the risk of theft.

Methods to assess deer impacts on vegetation

(*Text and references* taken directly from Davis, 2018 which appears as Appendix D to this document)

A new method for monitoring deer impacts on vegetation was developed to meet the requirements of land managers. This was a standardised, repeatable technique to monitor changes in vegetation. It was simple and rapid to implement, and could be applied in a wide variety of vegetation communities, ranging from wetlands to forest.

Vegetation was surveyed in permanent 10 m × 10 m plots and compared between Treatment and Reference sites. Vegetation variables were estimated using quadrats rather than transects because many of the EVCs being sampled occur in small patches and quadrats, Thus, the possibility of sampling units extending beyond the study area of interest, which could happen with transects, was avoided.

Permanently marked quadrats of 10 m × 10 m were selected because they have been used to quantify Rusa deer impacts in littoral rainforest, sandstone gully forest and sandstone heath (Moriarty, 2004*). In some studies, larger quadrats were selected to quantify deer impacts on highly heterogeneous environments or rainforest characterised by features such as large trees and canopy gaps that may dominate small vegetation plots (e.g., 20 m × 20 m; Davis, 2017). In this study 10m × 10 m plots were considered large enough to assess the parameters of interest, and small enough to allow rapid assessments to be undertaken.

Although designed to be simple to implement, this method did assume a moderate level of botanical knowledge, or capacity to access expert assistance to identify plants. This is important because the impacts of novel herbivores are related to relative consumption levels of different plant species (Nuttle et al., 2014*).

There is evidence to indicate that Sambar browsing and trampling can reduce ground layer and understorey vegetation density, prevent tree recruitment and facilitate weed establishment, leading to overall impacts on species diversity and structural integrity–with potential flow-on impacts on canopy cover and tree species diversity (TSSC, 2008, Bennett, 2016).

Three key vegetation attributes were selected for monitoring because they are known to be impacted by Sambar and other deer species in vegetation communities elsewhere (Forsyth et al., 2015, Deer monitoring protocol – Lake Tyers 26 Davis et al., 2016). These attributes could be quantified without sophisticated training and equipment: 1. Structure, composition and diversity; 2. regeneration and survival; and 3. vertical growth.

Structure, composition and diversity

Vegetation structure was assessed using three methods. First, changes in the structure of vegetation < 2 m in height was assessed using a structure pole. Second, changes in the structure of the ground and canopy layers were assessed using visual estimates of cover. Third, standardised photo points were used to provide a qualitative visual record of temporal changes in vegetation structure of all vegetation layers. The first and second methods also assessed changes in composition and diversity.

Changes in the structure of the ground and shrub layers were assessed using a structure pole to record foliage density at different height increments. To correspond with vegetation layers and the range of deer browsing heights, the structure pole estimates were made at five height increments: 0–20, 21–50, 51–100, 101–150, 151–200 cm (modified from Bennett and Davis, 2017). Anecdotally, a lack of recovery of some species from deer browse damage, once deer are no longer using an area, has been observed, particularly when a browse line has been established. The structure pole assessment quantified impacts, as well as recovery or lack thereof, of changes in vertical structure of the vegetation.

Changes in the structure of the ground layer were assessed using visual estimates of cover of ground layer categories. The cover assessment was undertaken within replicate 1-m2 quadrats. Ground layer cover estimates (percentage cover; continuous scale 0–100%) were made for material ≤ 50 cm in height for 14 categories: bare ground, litter, rock, coarse woody debris (dead wood ≥10 cm diameter), forb, grass, sedge/rush, lily, orchid, fern, shrub/tree, climber, moss, and other cryptogams. Bare ground was included as an index of disturbance, as it can facilitate weed invasion and soil erosion. In addition, cover estimates (percentage cover; continuous scale 0–100%) were recorded for the canopy (emergent and upper-canopy combined; and mid-stratum M1 and M2 combined (Figure 19). These canopy and mid-stratum estimates captured changes in vertical structure at a height greater than the 0– 2 m estimates recorded by the structure pole.

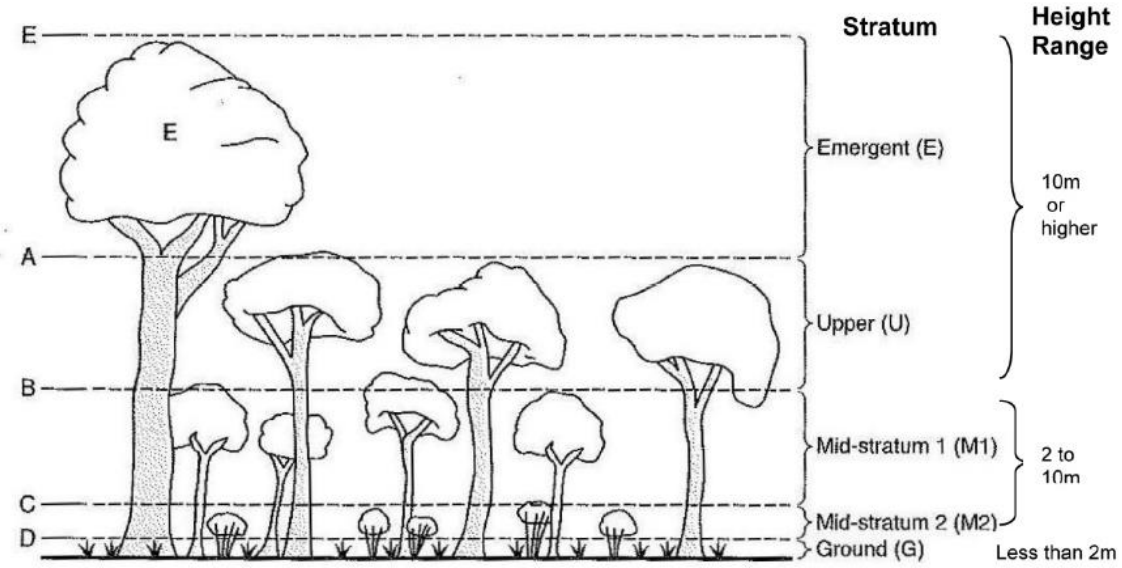


FIGURE 19: DIAGRAM OF VEGETATION STRUCTURE (HNATIUK ET AL., 2009, DAVIS, 2018)

Vegetation regeneration and survival

Quantification of tree age structure by species provides an indication of whether regeneration is occurring (Bennett, 2016). To assess deer impacts on regeneration, one should consider seedling establishment, survival, and size-class recruitment (Bressette and Beck, 2013). To quantify recruitment of woody plants of different genera into different size-classes (and in turn estimate establishment and survival), stem counts were made for all live and all dead individuals in vegetation plots of each woody plant genera. This method was expanded from Davis (2017) to include shrubs and woody vines, but with simplified size-classes (Bennett and Davis, 2017).

Initially it was proposed that counts be made within three DBH (cm) size-classes: < 2.5, 2.5–10, >10. However, preliminary field trials showed that this approach was not feasible due to extremely high seedling densities in some rainforest plots. Stem counts were therefore reduced to the larger two DBH size-classes only: 2.5–10, >10.

The use of two size-classes reduced the time required to conduct vegetation surveys, and it also reduced the influence of large masting events in rainforest with high levels of natural mortality of seedlings. Impacts of deer on survival and size-class recruitment was detected using counts of stems that reach the larger size classes.

Species-level information can be important when some plant species are preferentially browsed or rubbed, or less tolerant of browsing, rubbing or trampling damage, and these are replaced by other species that are avoided and/or tolerant of these impacts. However, stems counts were conducted for genera rather than species, because identification of juvenile plants was difficult and relative preferences of deer, and plant tolerances to deer, were broadly similar among species within a genus. For multi-stemmed trees, only the largest living stem were included in the count. Collection of genus-level data also added to the assessment of changes in composition and diversity.

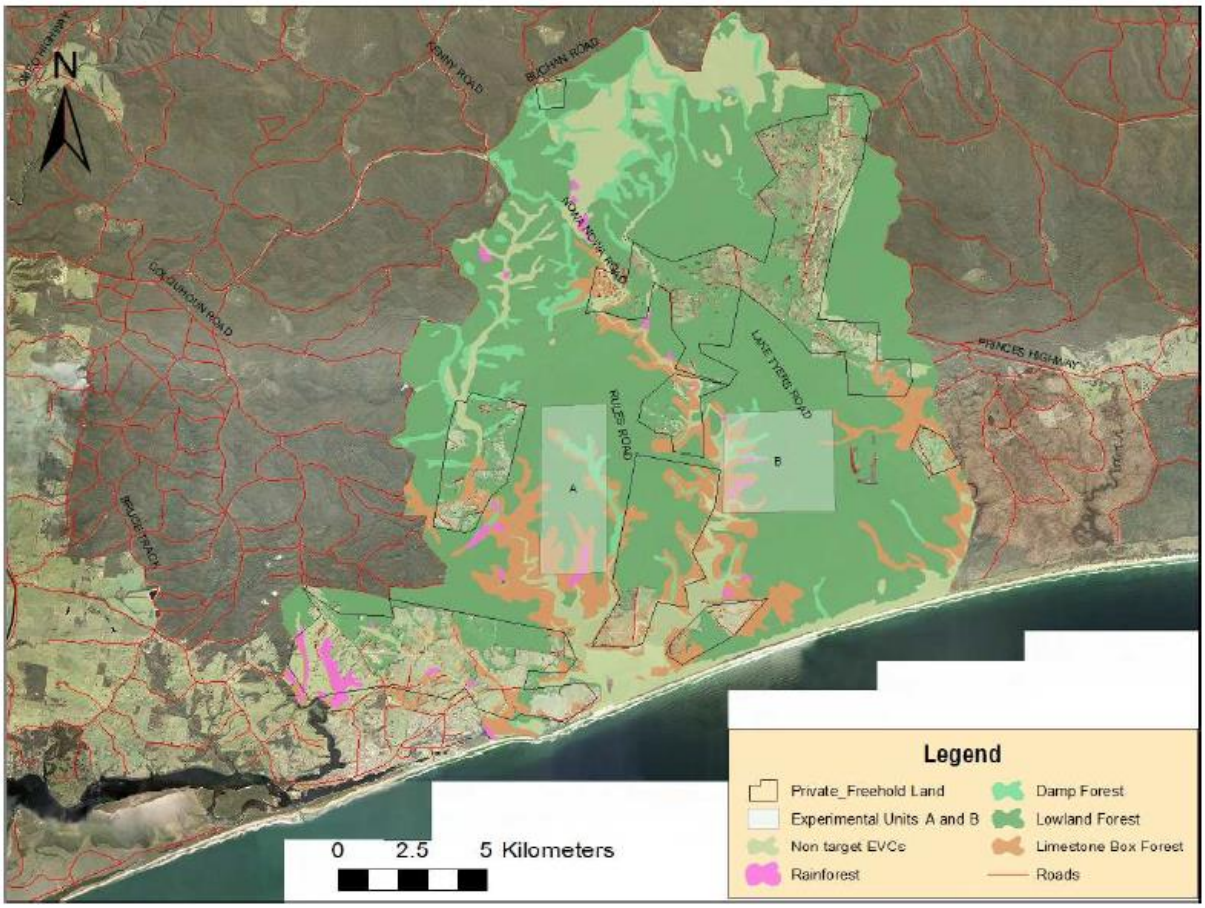


FIGURE 20: BROAD VEGETATION TYPES WITH THE LAKE TYERS PROJECT TREATMENT AREA

Vegetation growth and survival

Vertical growth of select understorey and mid-storey shrub and tree species that appeared to be targeted by deer were measured via tagging. Tagging individual plants is a useful method to assess the impacts of deer on plant growth (Husheer and Robertson, 2005). This method is labour intensive when detailed measurements are taken to assess the growth of individual

branches (e.g., Bennett, 2008), however, simple measurements of plant height can be used to demonstrate deer impacts on growth (Davis and Coulson, 2010) and are rapid to implement.

The method is considered simple enough to be implemented without extensive botanical skills, however, measuring vertical growth on all plants present without identifying species is not advisable. This is because deer preferentially browse some plant species while avoiding others (Nuttle et al., 2014*), hence the occurrence of both negative and positive effects on growth rates may mask impacts.

Growth was therefore assessed over time on tagged individuals of five plant species that are easily recognisable, widespread across many vegetation communities in the Lake Tyers area, and for which anecdotal impacts of deer have been observed: *Exocarpos cupressiformis*, *Pittosporum undulatum*, *Pomaderris aspera*, *Indigofera australis* and *Coprosma quadrifida*. Each of these species is heavily browsed by deer, as evidenced by a distinct browse line on these species in the Lake Tyers area. Each of these species is common across the landscape in the Lake Tyers area, although *P. undulatum* tends to be a pioneer species and is not as widely distributed. *Acronychia oblongifolia* is also heavily impacted on by deer (Peel et al., 2005) but was not included as a target species for tagging because it only occurs in rainforest. As well as providing information on growth, this component of the monitoring provided data on survival of tagged plants.

Deer damage to vegetation

Documentation of physical damage caused by deer such as antler rubbing does not necessarily provide evidence of consequences for plant fitness or survival (Davis et al., 2016). This project moved beyond quantification of this type of damage, to examining its consequences for vegetation communities. However, quantification of physical damage by deer can help to partition the impacts of deer from those of other species (Davis et al., 2016). This was important for this project, given that deer impacts at Lake Tyers are not partitioned from those of other herbivores using experimental exclosures.

Deer cause damage (through browsing and antler rubbing), such as apical bud removal, bark stripping and fraying, flower removal and stem breakage (Barrett and Schmitz, 2013*). It has been suggested that deer browsing can be differentiated from that of other species due to differences in bite characteristics (e.g., rough-torn edges for deer; Strole and Anderson

1992*). However, Stockwell (2003) found that it was not possible to quantify these differences in the field. Therefore, this study broadly attempted to quantify the degree of browse damage in combination with an assessment of antler damage (rubbing and thrashing) and bark stripping.

Data from browse damage scores can be analysed to compare levels of damage between groups of plants (Marks and Moore 1998), with physical evidence of deer damage categorised for all tagged plants.

Monitoring data collected before and after management interventions which had been implemented for three hunting seasons was then used to statistically evaluate and examine what, if any, changes resulted in the response variables (deer relative abundance and vegetation condition). Metadata from camera images was extracted using ExifPro, with further data collation and analytical methods developed by 'The Analytical Edge' consultancy (available as Appendices D through I).

Results

Area Hunted

1005HA of private land or 12% of the total within the project area was hunted. 8892HA of the Park was hunted. This was basically all the Park in the project area except small sections close to towns.

11330HA or 65% of the 17427HA of state forest within the project area was hunted. All up, of the 38000HA project treatment area, 21227HA or 55.8% was subject to hunting activity during the project's three year timeframe. (See Figure 22).

FIGURE 21: GLAWAC IN LITTORAL RAINFOREST IN THE TREATMENT AREA

Hunter effort and return

The level of hunting activities varied across the Treatment/control area between and within specific land tenures where hunting pressures were deliberately elevated. Hunter activities also varied as the project progressed through its three years of delivery. The early stages of the project (2019 hunting season) saw the most rapid growth in the number of hunters, while 2020 saw the largest growth in the area hunted and number of private landowners actively engaged in the project.

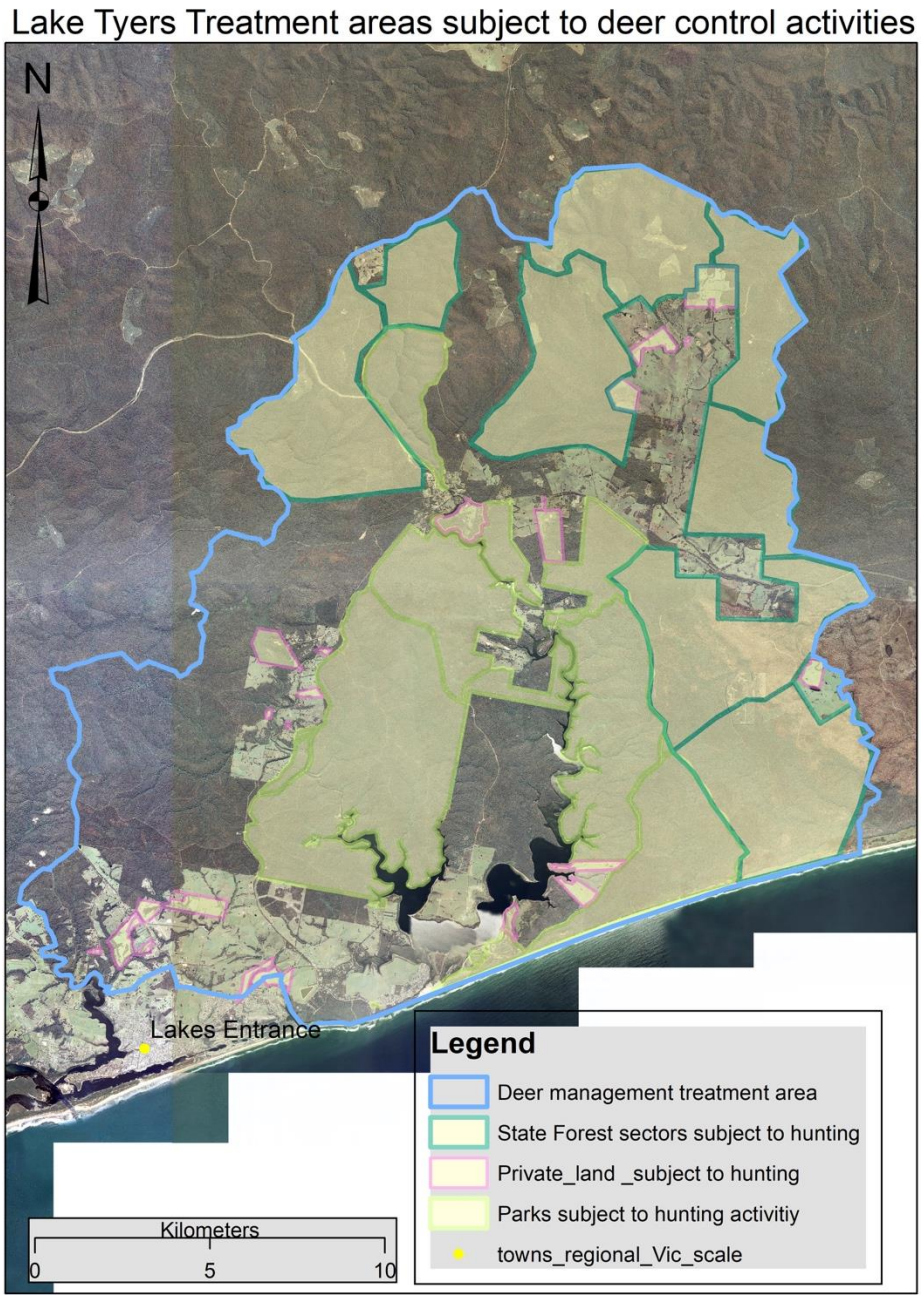


FIGURE 22: LAKE TYERS DEER PROJECT TREATMENT AREAS

During the early, pre-covid stages of the project, Far East Victoria Landcare network (FEVL) and their Wairewa Landcare Group were introduced to and partnered with members of the Australian Deer Association (ADA) and the Sporting Shooters Association of Australia (SSAA), to support delivery of deer control on private and adjoining public land in the Wairewa Valley and surrounding area.

In the first year, within the north-eastern section of the project area, volunteer contribution toward control activities involved around 36 volunteer hunters. They collectively contributed

over 1120 hours – attending meetings and planning days, then coordinating and delivering control activities.

This volunteer effort resulted in the reported removal of 78 deer during the first year of the project from the north-eastern section of the Treatments area.

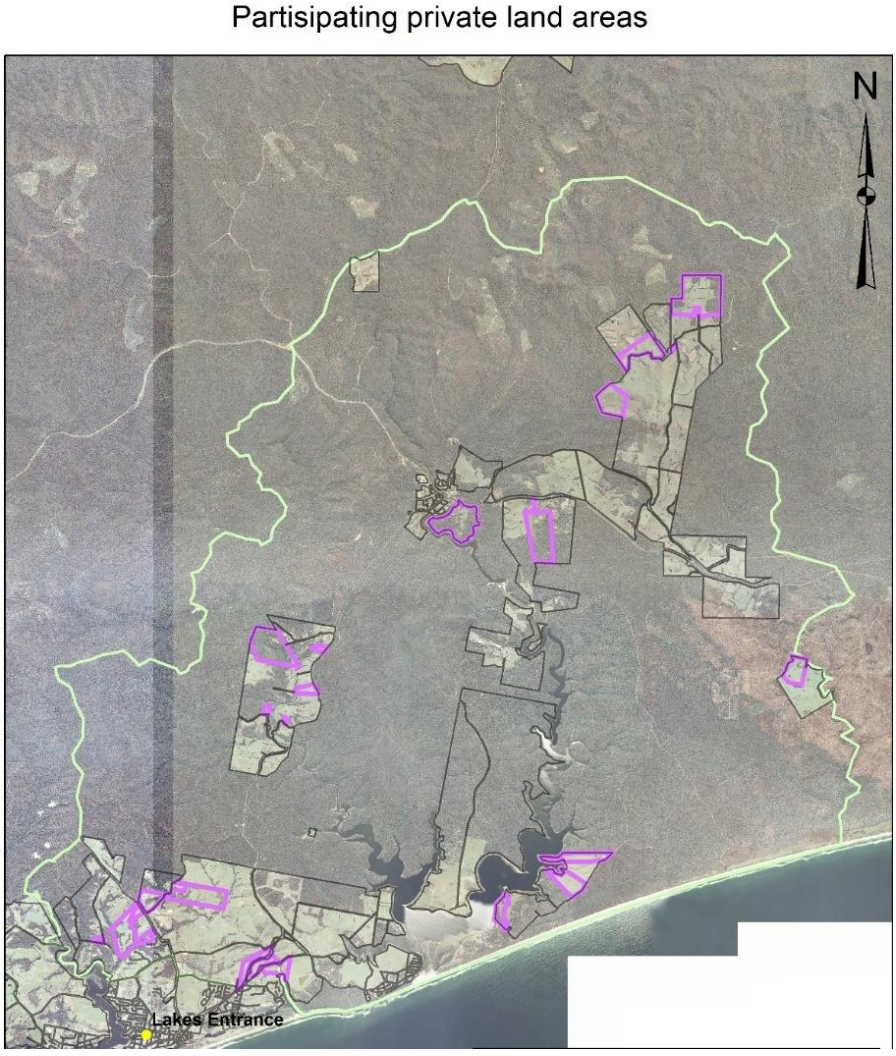


FIGURE 23: PRIVATE LAND WHERE HUNTING OCCURRED

Coordinated hunting activities on private land within the Treatment area occurred across at least 26 private holdings over the three years of the project (See Figure 24 above). This was delivered by a mix of recreational hunters and landowners, directly covering a land area of just over 1000HA or around 12% of all private land in the Treatment site. Properties ranged in size considerably from 1.8HA to over 140HA and contained a wide array of native vegetation cover and improved pastures.

Deer control activities are known to have an effect on deer populations (impacts/behaviours) beyond the immediate area where control activities have actually been delivered (Almendinger et al, 2020). For reporting purposes this distance is 200m. This buffer was taken into account, within the project footprint. Where hunting activity was undertaken, and influenced deer numbers or behaviours, private land increased to around 2700 HA or around 31% of the ~8700 ha of the project control area.

A majority of participating hunters did not submit individual data sheets, irrespective of repeated requests or their prior commitment to do so. This resulted in an inability to accurately quantify the overall hunting effort.

Estimates and extrapolation, however, based on data that was submitted indicates that:

1. Around 30 ADA members, 10 hunters affiliated with SSAA, and around 8 of the private landowners themselves, actively participated in hunting deer across the 26 private land properties within the project Treatment site.
2. Individual hunters reportedly spent on average ~9 hours per month hunting deer and removed/shot a deer for every ~4 hours, on average of hunting time.
3. It is estimated that an average of 15 deer were removed from each property over the duration of the project and a total of around 390 from private land overall (although reporting and estimates vary considerably).

Private land control efforts

In multiple circumstances landowners were found to already be undertaking deer control activities on their land and in some cases also within surrounding state forest areas.

While the effort contributed toward project outcomes from both private landowners and recreational volunteers' hunters was significant, the amount of data supplied was substantially less than anticipated. Despite this, data from several landowners and multiple private land hunting operations allows an informed approximation of the overall hunting effort made.

In some cases, the efforts were substantial. For example, records submitted by the Australian Deer Association show, from one member's records, that 17 deer hunting operations were conducted in the second half of 2020 (June to November) in conjunction with at least one

other person/member across at least four sites. This resulted in the removal of seven deer with an average hunt time of three hours.

In one private landowner's report, their self-conducted hunting effort was maintained throughout the duration of the project but at fairly low level (three to four hours a month), with the number of deer taken (10) fairly evenly spread out over the two years.

In another example, on the western flank of the project area in the Baades/Harrison block (see Figure 12), multiple hunters were able to apply significant hunting pressure to a private land section of the project Treatment site. The site was visited 49 times, at an average of 4 hours per visit, for a total of around 196 hrs of volunteer effort. 26 deer were removed (one deer removed ~every 7 hrs) over a two-year period from a 9HA parcel of land.

Not far away in the Hoggs/Bunga Creek Block (Figure 12) another landowner on a 70HA property removed 13 deer over the project's duration (6 deer in 2019, 5 in 2020 and 2 in 2021). This landowner spent an average of 4 hours per animal or 52 hours of volunteer time in total.

In the Toorloo Arm Block (Figure 12) 6 deer were removed from a 13HA private block in the 18 months to December 2021. Volunteer hunters offered assistance on around 10 occasions and spent on average 4-5 hours each visit.

Another private landowner reported hunters spending an average of 5-6 hours a night, and a couple of hours the next day checking and retrieving parts of the carcasses, with 8 deer removed over a 5-month period.

Another area known to have been undertaking deer control for over a decade, removed an additional 20 animals over the course of the project, with an average hunt time of 3 hours per animal removed.

Trust For Nature deer control

During the time period June to December 2021, Trust for Nature undertook deer control activities across multiple Trust For Nature covenanted properties using professional and volunteer hunters within the Treatment area, as part of their bushfire recovery work. This work targeted deer across five properties totalling 105HA over 12 nights (around 72 hours hunt time) and removed 28 deer (approx. one deer for every 2.5 hours of hunting effort).

Deer control with Lake Tyers State Park

The 2019/20 summer bushfires and subsequent government funding for biodiversity management, saw a coordinated deer reduction program in the Lake Tyers State Park. The program was coordinated by Parks Victoria and commenced in August 2020 and was still running at December 2021.

The works also incorporated several private land holdings adjacent to the Park's south eastern extent. This is an area which was also targeted by recreational hunters on multiple occasions in the previous year.

FIGURE 24: A SIGN INFORMING PUBLIC PARK VISITORS OF DEER CONTROL ACTIVITIES AT LAKE TYRES.

Between August 2020 and June 2021:

- Number of operations = 9
- Number of deer taken = 340 confirmed to be Sambar
- At time of writing an additional 34 Sambar had been taken during November and December 2021 bring the total to 374.
- This was mainly one team of two staff across 37 nights (10 hours each night)

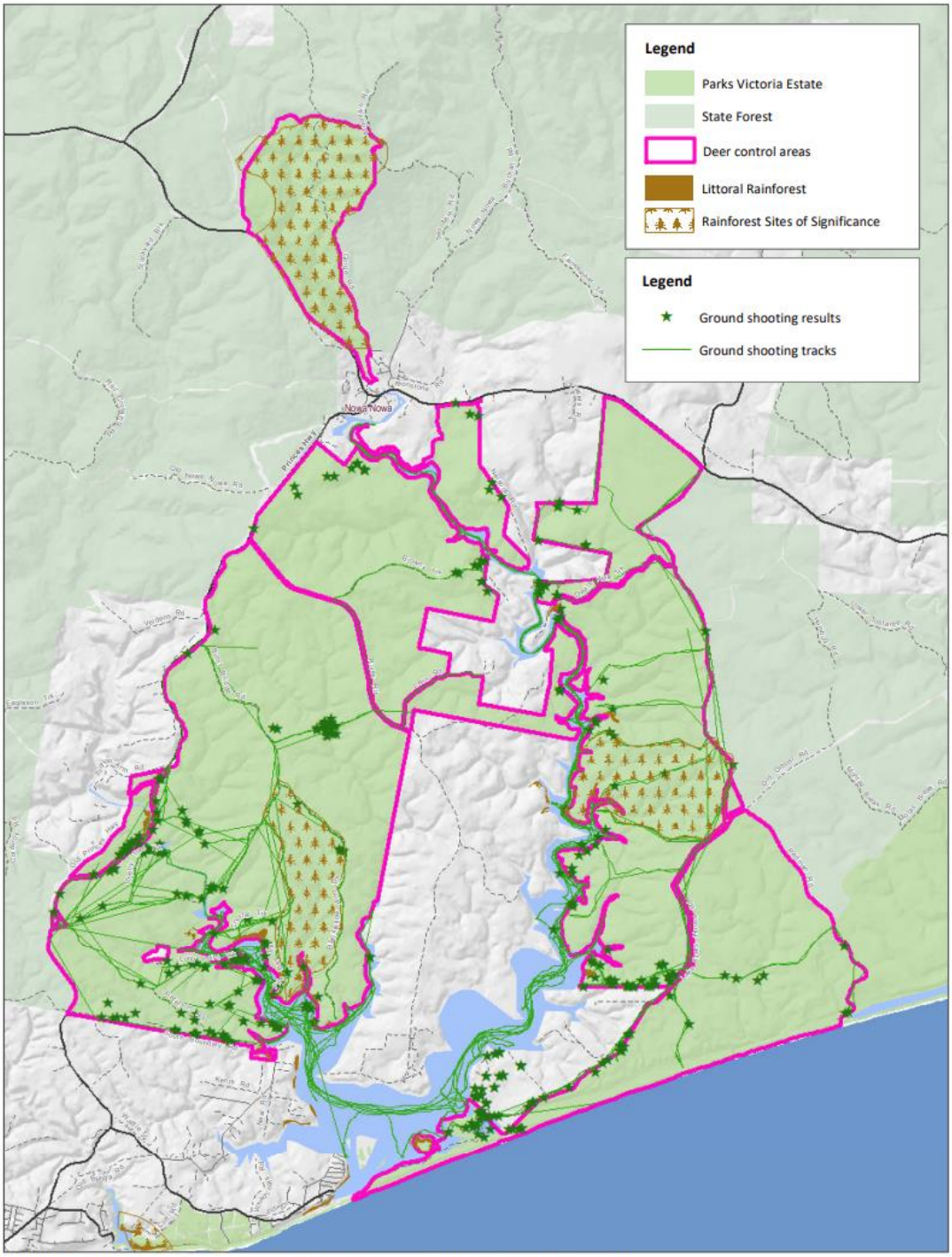


FIGURE 25: CONTRACTED DEER CONTROL IN LAKE TYRES STATE PARK

Monitoring results and analysis

This section should be read in conjunction with the methods in appendices E through I.

Monitoring vegetation condition via use the target 160 Vegetation plots and deer relative abundance via 80 infrared cameras, occurred in the winter of 2019 at project commencement and again during the winter of 2021, after roughly three years of deer control.

Resulting data was analysed by 'Analytical edge' in late 2021 with the following findings (full reports and methods available as Appendices E-I)

Camera trap data

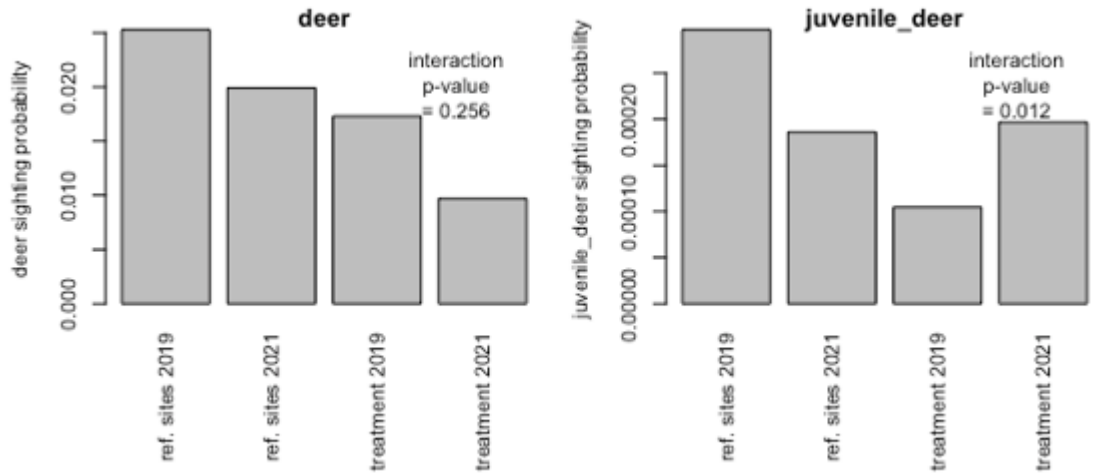


FIGURE 26: DEER SIGHTING PROBABILITY BETWEEN SITES AND YEARS

Camera trap deer sightings were highest at Reference sites in 2019, but went down at both Reference sites and Treatment sites, but slightly more at Treatment sites (non-significant result).

Camera trap juvenile deer sightings were highest at Reference sites in 2019, but actually went up at Treatment sites, but not Reference sites (significant result).

The relative probability of a deer sighting was reduced more in the Treatment sites than the Reference sites. The ratio of change (probability of a sighting on a given day in 2021 /

probability of a sighting on a given day in 2019) in Treatment compared to the Control sites was 0.72 This ratio was not significantly different from 1 (p-value = 0.256).

Ground cover

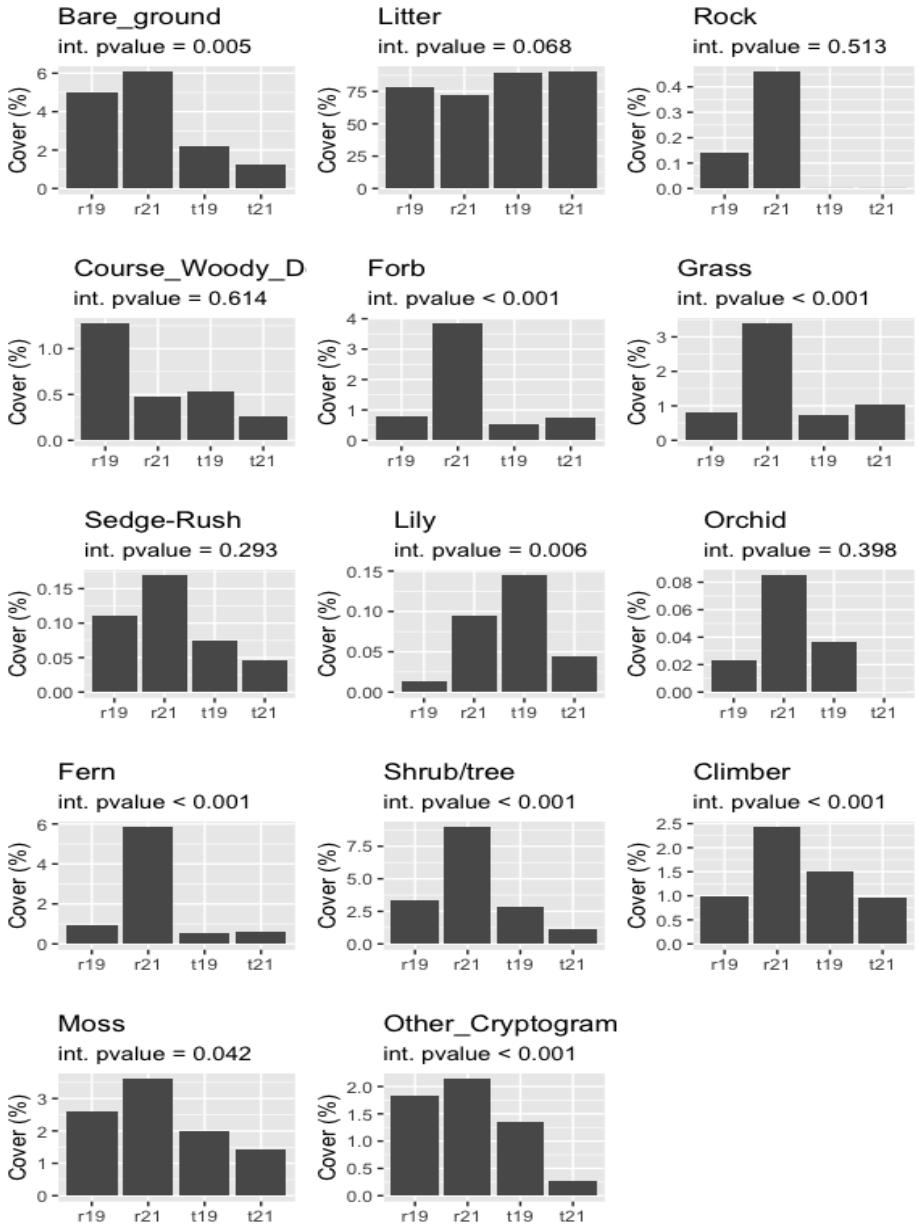


FIGURE 27: GROUND COVER FOR REFERENCE/TREATMENT SITES IN 2019 AND 2021

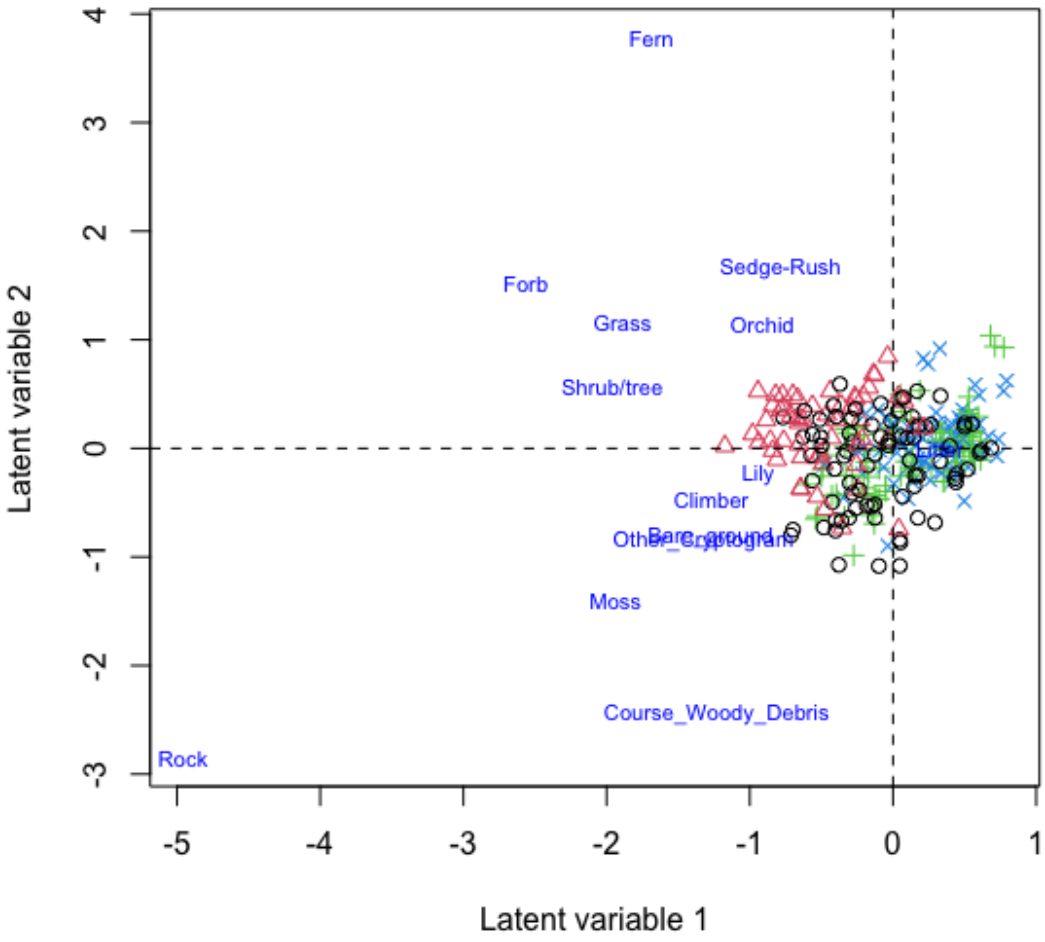


FIGURE 28: ORDINATION PLOT OF GROUND COVER VARIABLES FOR YEAR 2019 AND 2021

In the above Ordination Plot: Black circles represent Reference sites in 2019, Red Triangles represent Reference sites in 2021, Green +'s represent Treatment sites in 2019 and Blue x's represent Treatment sites in 2021.

Treatment sites show significantly lower change in cover (2021 cover - 2019 cover), relative to Reference sites for bare ground, grass, sedge-rush, lily, shrubs/trees, ferns, climbers, forb and other cryptogram. These are the cover types that showed significant interaction p-values.

Figure 28 gives the estimated percentage cover for all cover types at Reference and Treatment sites in 2019 and 2021.

The estimated percentage cover of bare ground increased from 4.9% to 5.8% at Reference sites, while it decreased from 2.1% to 1.3% in the Treatment sites.

There was significantly less litter at the Reference sites in 2019 (77.9% vs 88.9%). In 2021, the amount of litter decreased to 71.7% at Reference sites, while it increased to 89.8% at Treatment sites. These changes were not significantly different between Reference and Treatment sites.

Vegetation growth/deer damage

These results look at the difference in deer damage score as monitored by tagged plants in the vegetation plots (see methods at Appendix F).

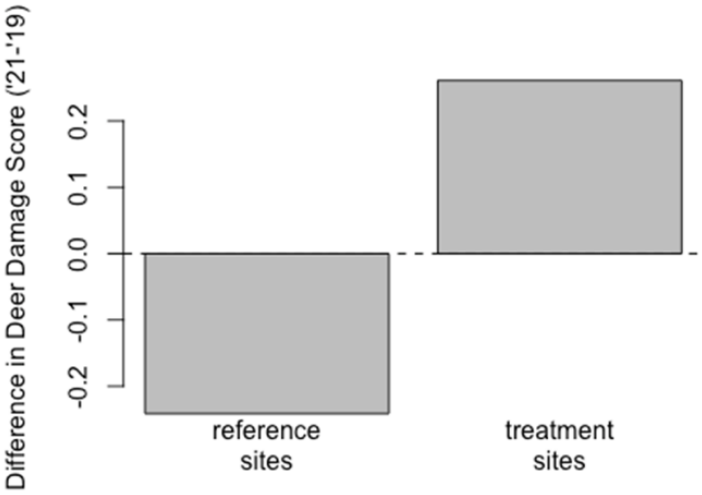
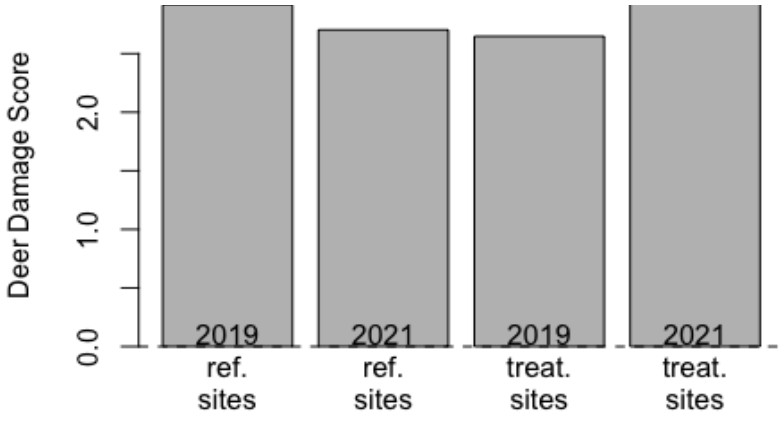


FIGURE 29: ESTIMATED MEAN DEER DAMAGE SCORE FOR REFERENCE & TREATMENT SITES IN 2019 & 2021



The results show that deer damage score has gone up for Treatment sites, but down for Reference sites. While these

differences were small (±0.25), the difference between Treatment and Reference sites was significant ($p<0.001$).

Vegetation regeneration

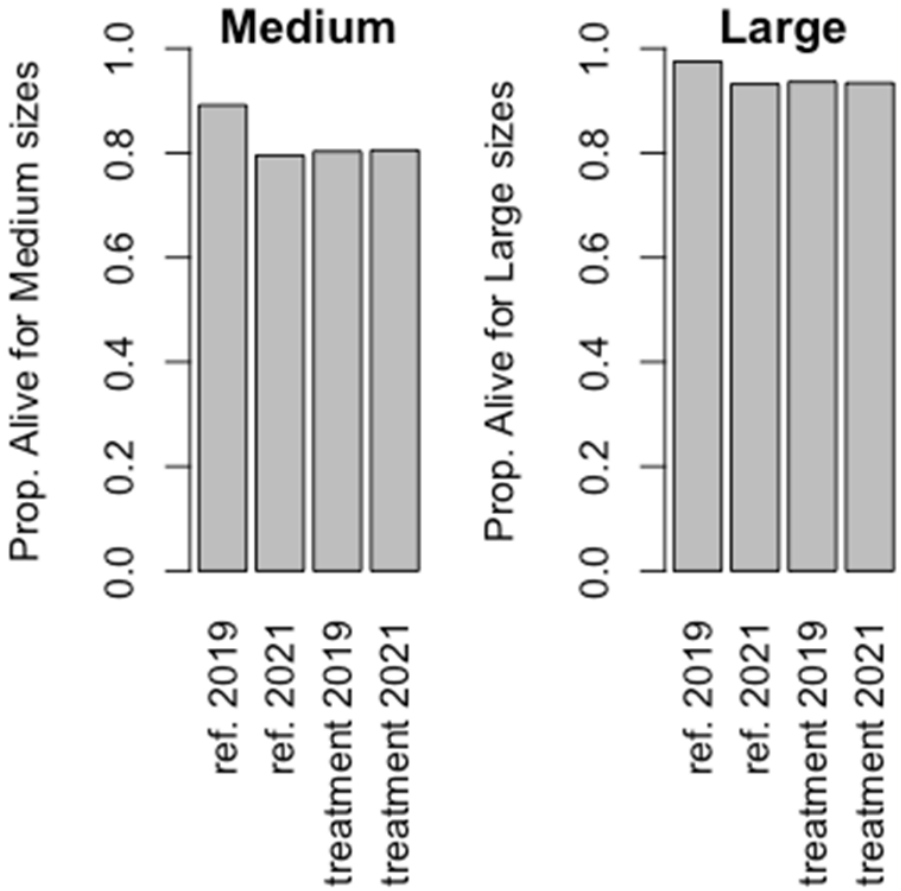


FIGURE 30: PROPORTION OF PLANTS ALIVE

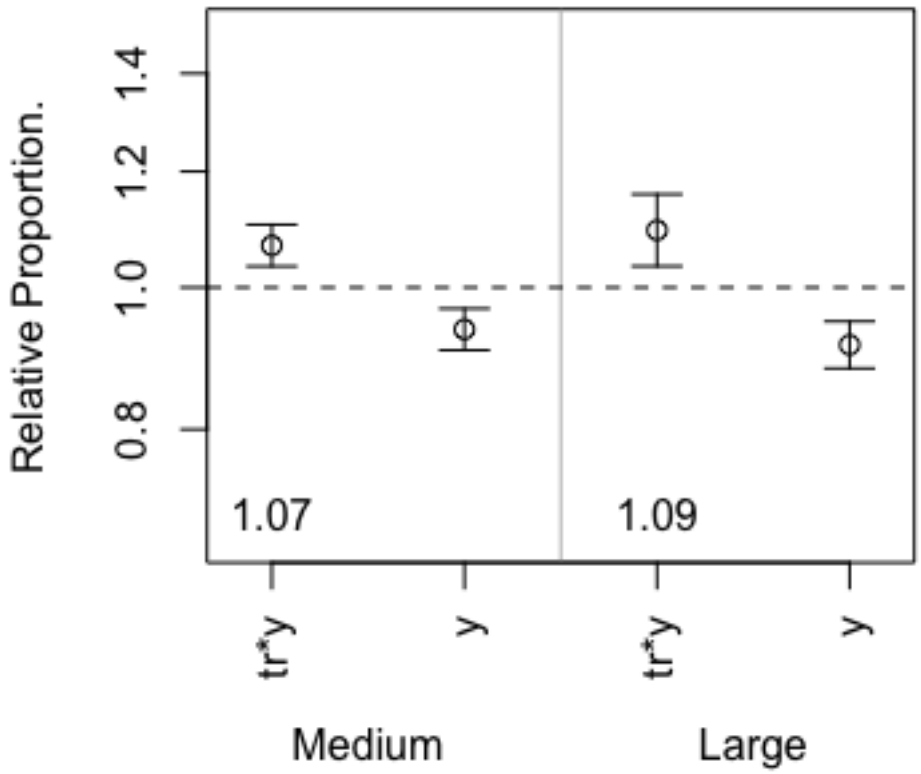


FIGURE 31: RELATIVE PROPORTION OF ALIVE PLANTS

The relative change in proportion of alive plants was 1.07 and 1.09 times larger in Treatment sites relative to Reference sites for medium and large plants respectively (Figure 31). These relative change in proportions were both significantly different from 1. More specifically the proportion of alive plants decreased at Reference sites, but stayed relatively constant at Treatment sites

Structure pole

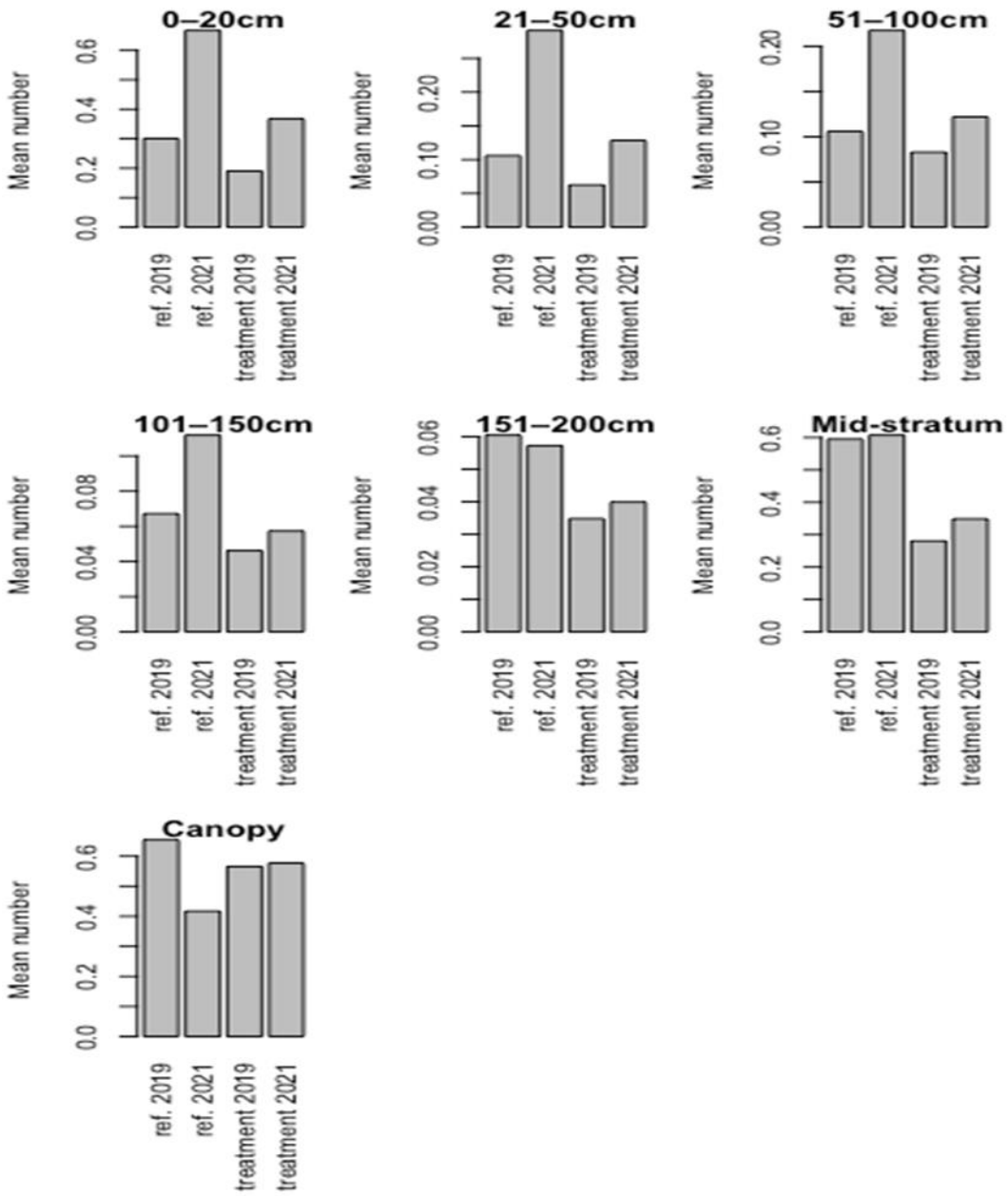


FIGURE 32: STRUCTURE POLE RESULTS

The total number of structure pole 'hits' (a proxy for vegetation density) is significantly greater for treatment relative to reference sites at heights; Canopy and Mid-stratum.

The total number is significantly less for treatment relative to reference sites at heights; 21-50cm, 51cm-100cm and 101-150cm.

Discussion

Monitoring

Camera trap data showed a greater reduction in deer relative abundance in the Treatment area, where coordination elevated hunting pressure, than in the Reference area where hunting pressure was not as high, suggesting that deer control activities including deer removal and/or hunting pressure may be responsible for the observed changes in deer distribution and relative abundance. However, as deer relative abundance was also shown to decrease, albeit to a lesser extent, in the Reference area and the difference in results from the different areas are not considered statistically significant, the observed change in the Treatment area could also be due to other factors and cannot be solely attributed to our management intervention.

Changes observed in groundcover were found to be more pronounced at Reference sites relative to Treatment sites overall (less change observed in the Treatment area) which is unexpected given deer's capacity to alter ground cover.

Bare ground was lower in Treatment relative to References in 2019. The percentage cover decreased further in Treatment sites, while it increased in Reference sites. This may be due to reduced deer numbers. However, grass significantly increased more in the Reference sites than the Treatment sites. Results may be confounded by other factors, such as different amount of fire impacts between Reference and Treatment sites (although sites that were impacted by fire were removed from the analysis).

This result may either reflect differences in site characteristics and conditions (wetter at Reference sites) or other attributes not related to deer over the time frames involved.

Deer damage scores were assessed at the plant level, on tagged plants. The results show reduced levels of deer damage in Reference areas, somewhat counter intuitively, where coordinated control activities did not occur and showed increases in deer damage scores where control measures were implemented. These differences were small (±0.25), but the difference between Treatment and Reference sites was significant ($p<0.001$). While this is contrary to what may have been expected, it may be possible that slightly reduced deer

numbers allowed new individuals to move in and 'have their turn' on the selected plants, known to be targeted as part of deer social and territorial behaviors (the sump effect).

With the deer damage result taken from specific species known to be especially targeted by deer, it is logical to assume that a similar result could be expected for other species and the overall regeneration of other species or the vegetation as a whole. However, this does not appear to be the case, with an overall trend toward increased vegetation thickness or structure evident from the structure pole data from most height class categories (Figure 33).

Notwithstanding the general trends noted above, for most strata and locations, there is a more pronounced increase in mid-strata and canopy structure at the Treatment sites. Such results are also unlikely to be the product of management interventions, as such developments are out of deer browse height and assumed to take longer than has been allowed to become observable. Rather, they may relate to or indicate pre-existing differences in vegetation structure between the sites, a trend which if present would likely become more evident with time.

The Structure pole results show a general thickening of the vegetation from 2019 to 2021. With a significant difference observed between the Treatment and Reference areas, with the latter found to be thicker (more pole hits). A result which is the opposite from what was expected. Though is likely best explained by other extraneous site related variables (forest age, successional stage) and importantly the breaking of the drought driving a flush of vegetation growth.

Results for regeneration (see Figure 31) showed that the Treatment sites where deer control had been undertaken, had significantly more alive plants in 2021, relative to 2019, than Reference sites where deer control was not as elevated, which had experienced a decline in the number of alive plants. More specifically, the proportion of alive plants decreased from 2019 to 2021 in the Reference sites, while this decrease was not observed in the Treatment sites. This result was consistent for both medium and large plants and suggests regeneration processes, across all target vegetation types, as a whole may be facilitated or associated with deer control activities.

Variation was greatest between sites, and the variation between units was negligible relative to the variation between sites, suggesting that this difference is more likely attributable to the

hunting management intervention than inherent differences in site characteristics. While this result is not entirely conclusive and is somewhat confounded by the reduction in tagged plant survivorship in the Treatment area, the result is encouraging and requires further testing and investigation to provide greater clarification of the relationship(s) between deer control and vegetation regeneration.

The Cross-tenure approach and project partnerships

The project has been highly successful in procuring, nurturing and maintaining project partners. Partners included multiple local Landcare groups, Traditional Owners, government land management agencies, recreational hunting organisations and many other non-affiliated individuals. In fact, the project's capacity to build enduring partnerships around deer control has possibly been one of the projects biggest achievements.

As there was a lot of volunteer effort associated with delivery of control activities, this required a lot of engagement, planning and coordination to enable successful outcomes. The

FIGURE 33: RAINFOREST AT LAKE TYERS STATE PARK

uncertainty around consistency of participation and the quality of contribution was always an unknown.

This risk was mitigated to some extent, with the engagement of two Wairewa Landcare members and the president of the East Gippsland Branch of the ADA stepping up as project champions to support operational delivery. They were members of the operational working group and worked closely with the project team to ensure success, particularly in the project's initial stage.

ADA took an active role in the organisation of individual hunters and collective engagement throughout the project. ADA conducted multiple group-based control activities (hound hunting for example) which were found to be highly effective. Other small teams of ADA affiliates were also able to employ thermal night vision to great effect within select private land areas, further elevating hunting returns.

SSAA also engaged with the project, hunting in areas of private land and state forest. At an organisational level however, the SSAA opted at the onset, to be less actively involved in the coordination of its members, something that persisted throughout the duration of the project. This placed a much greater organisational and administrative responsibility on project staff, which at times saw a lower level of systematic coordination achieved than that observed within the ADA.

A key learning from this project is that the coordination of recreational and other hunting at scale is both costly and resource (time and money) intensive. Our results also suggest that while recreational hunting may be one element of effective control, it has, in this instance, been less effective than utilising contracted hunters who appear to provide greater return on investment. This result could be better clarified if recreational hunters were more willing to contribute data in relation to hunting effort and return.

It is understood that few if any other deer projects have been able to deliver deer control activities at scale, cross-tenure (>10,000HA). However, complexities inherent in such work can demonstrably be overcome via a partnership-based approach, which coordinates activities in a cross-tenure fashion. This project demonstrated the ability to facilitate and successfully coordinate deer control activities across all major land tenures within the project footprint–

an area in excess of 20,000HA, albeit with some difficulties experienced in areas of State Forest, relative to other tenures.

Hunting effort and reporting hesitancy

Hunters agreed to provide data on effort and return when signing up to the project–but most consistently failed to do so. While it is possible to extrapolate existing data to provide a reasonable approximation of both hunting effort and deer take, this clearly does not provide the optimal resolution of information from which to make observations or draw conclusions.

It is suspected that part of 'hunt reporting hesitancy' is due to sense of ownership over particular hunting areas–and a desire to maintain access to the 'resource'.

There was also a 'digital divide' element, with several hunters expressing difficulty in using online reporting options. We hoped to manage and overcome this by providing additional support to hunters to use our existing reporting systems. We also worked with hunting associations who are developing a mobile phone application for this specific purpose.

Many hunters cooperated well and the level of cooperation from the major hunting organisations was a key beneficial attribute of this project. However, at an individual level, competition between hunters was an observed trend in this project. This occurred across all years.

Similar to the recreational fishing community, deer hunters often seem to develop a personal affinity with locations. Over time this was observed to affect their willingness and/or capacity to coordinate or share hunting areas–and in some instances the sharing of hunting information. Having somebody else 'cut your lunch' ie; hunting in the same area, is generally disliked.

Project managers also found that some private landowners who were already undertaking control activities did not want 'other hunters' on their land. This attitude extended into the surrounding state forest areas which in several instances was viewed and labelled as 'their patch'. In two instances, this was evidenced in private landowners not wanting adjacent forest hunted to 'keep the peace'. This resulted in several areas (state forest hunt sectors) being

removed from the maps supplied to new hunters, despite known opportunities to successfully hunt/control deer.

Hunting in the Park

Hunting and deer control activities within the Lake Tyers Park were always intended to occur as a component of this project. However, funding made available for deer control as a result of the 2019/20 Black Summer bushfire disaster further enabled this to occur, with multiple operations delivered under the guidance of Parks Victoria.

Importantly, the efforts of professional/paid hunters were able to be maximised by leveraging the investment in relationships established as part of this BRP funded project. Shooting on private land increased the area subject to control. Specifically, several private land properties in the far south of the project area, at the end of Glass House Road were negotiated with and subsequently made their land available for contracted hunting. These properties were used to expand the reach of the control work on multiple occasions. The removal of animals from the private land was also increased by using a barge on the Lake from which to shoot and recover the deer.

Deer control within this area was undertaken solely by professional, contract hunters. This proved to be highly effective. On average, 1 deer per hour was taken, with nearly 400 deer removed altogether from with the Park's estate and a relatively small section of private land.

This work demonstrates both the proficiency of contracted professional hunters– and also their ability to accurately report operational information to a level not experienced from the majority of the recreation hunting community.

The contracted Park based control work also illustrates that the deer population in the project area is both highly abundant and mobile, with deer noted to be moving into the area previously subject to control from the adjacent Ewing Morass State Game Reserve within only a few weeks. This problem has been noted as common to such control efforts (immigration of target species from adjacent areas) by Burgsen et al., (2020).

It is worth noting the highly localised nature of deer control locations, with higher numbers generally associated with 'edge' environments. This also demonstrates the habitual nature of the target species.

Private land hunting

The facilitation and coordination of deer control and hunting activities on private land was overall, more successful than our attempts in state forest.

Mailouts were found to be an effective method to engage private landowners. The fact we had multiple articles in local newspapers was also mentioned on several occasions as alerting potential project participants to the possibilities. This made them more open to participation than would have occurred with a direct approach and appeal to join the project.

The complexities of facilitating access to in excess of 26 private land titles and the coordination of several dozen hunters delivering lethal force cannot be understated. It required a substantial investment of time and resources. In hindsight the ideal amount of time and resources was above and beyond that available to the project delivery team in this instance.

On more than one occasion, the operation did not go according to plan. Despite this, on almost all of these occasions, an amicable outcome was reached through good communication and a commitment to the partnership driven nature of the project.

On one occasion a hunter turned up to a landowner's house, with a junior in tow, without prior warning, gun in hand, assuming there was nothing wrong with such an action. Upon being promptly asked to leave the hunter was reportedly somewhat dejected and did not return. The site was fortunately picked up by other volunteer hunters.

In another instance, after gaining landowner consent and after the assigned hunter inspected the property, the landowner and hunter were informed of the neighbour's discontent with the operation and met with a request not to proceed. The neighbour's concerns were about deer 'running dead' onto their land and resultant loss of amenity. This claim was unsubstantiated, but nonetheless the landowner decided not to engage further with the project.

These incidents highlight the importance of clear and concise communications and understanding between participating hunters and landowners to ensure positive relationships endure.

While there are laws that ensure game hunters are appropriately licensed, and that specify the methods used and areas where hunting is permitted, questions were raised by multiple private landowners as to the effectiveness of such laws to regulate hunters. Concerns about hunter behaviour were cited by several landowners as a reason for not participating in, or being reluctant to participate in the project. Several private landowners reported poor behaviour from 'cowboy hunters', who had reportedly cut fencing and gained unauthorised access to sections of private land.

In one instance a violent altercation took place between a private landowner and volunteer recreational hunters operating as part of the project. This is believed to be in part related to a sense of ownership over the state forest and the resources it contains. The hunters subsequently decided to leave the area to hunt elsewhere–and also left the project.

Working with the hunting organisations to employ a system of hunter accreditation was found to allay some landowners concerns and provide the surety they required to join the project.

The area able to be influenced by hunting activities is believed to be larger than the actual area directly hunted. Deer impacts are clearly not limited to their immediate surrounding at the time of being shot. This is thought to be due to the buffering effect hunting pressure has on deer behaviour (becoming gun shy). (Mills *pers comms,* 2019; Almendinger et al, 2020).

When this buffer effect is taken into account, the private land area over which hunting activity has been undertaken and influenced deer numbers or behaviours within the project footprint is around 2700 HA or around 31% of the ~8700 ha of private land within the project control area.

One notable private land area where hunting was effectively excluded is the Lake Tyers Trust, the home of the Lake Tyers Indigenous community. The community has a specific policy in place which prevents the possession or use of firearms. This is an area of 1481HA of private land within the project area. This position/policy, upon approach, was found to be non-negotiable and that position was respected.

State forest hunting

State forest areas make up a significant percentage of the overall project activity area available for hunting. These are the only areas open to and able to be freely hunted by non-accredited project participants and other hunters.

It is understood that a considerable amount of hunting continues to take place within the state forest areas within the project Treatment site. Hunting pressure, as a result of this project, is believed to be elevated relative to other areas.

Many hunters expressed the view that state forest areas within the project area are difficult to hunt successfully and present challenges that would require significantly more resourcing (time and effort) to obtain a reasonable return for effort. For these volunteer hunters, this seemed to translate into a preference for hunting either the private land interface or to solely focus on private land, with conditions more conducive to a successful hunt.

Other hunters targeting state forest areas reported mixed results. Several reported spending considerable time, many days, hunting but not being able to find (or remove) deer. They reported this lack of hunt success as being due to the thickness or other conditions of vegetation, preventing an 'ethical shot'. Lack of hunting skills and experience could also have been a factor in the lack of success.

In the early stages of the project several groups of 'hound hunters' operated in conjunction with the project in areas of state forest around the Treatment area's eastern perimeter. They were able to achieve good returns for their efforts, removing up to 9 deer over a weekend in one instance and 6 on another occasion. Generally, they took animals on all or most of around a dozen trips, over several seasons.

Unfortunately, despite many efforts it has largely not been possible to quantify the overall hunting pressure applied to state forest areas or the return of the efforts made. This is due to several factors: the large extent of the area involved (~17,000HA); relationships with hunters not being formalised and an inability or unwillingness of 'unaffiliated' or 'loosely affiliated' hunters to report their hunting activities, despite prior commitment and encouragement in the form of information (maps, deer camera monitoring data etc). We know the areas of State forest which we hunted as part of this project (see results) but not the overall amount of time taken or the return on this investment.

Reference area hunting

The Reference area, being partly comprised of state forest where deer hunting is permitted, is known to be hunted and continues to supply opportunities for the recreational hunting community to seek Sambar deer.

While the absolute level of hunting pressure in this area remains unqualified, it is assumed to have remained relatively constant in relation to other areas available for hunting and to be consistently lower than in areas (around Lake Tyers) where hunting pressures have been actively elevated.

Recreational hunting is and was occurring in the Reference area, but is not thought to have been elevated during the course of this experiment. If anything, the level of recreational hunting may have been reduced. This reduction was firstly due to the impacts associated with the bushfire and secondly by restrictions arising from the Covid-19 pandemic (as discussed elsewhere). However, it is apparent both from images caught on camera and anecdotal evidence that some deer hunting pressure continues to be applied, albeit in an uncoordinated manner.

It is also of note that postfire recovery deer control work also took place within the vicinity of the project Reference area during the second half of 2020. But the extent of this work and its influence on deer population in the broader area, including this project's Reference site, remains unknown.

FIGURE 34: A RECREATIONAL DEER HUNTER WITH TRACKING DOG CAUGHT ON CAMERA

Impacts of fire, corona-virus and drought on project delivery

Fire

The Black Summer bushfires of 2019/20 were unprecedented in their scale and impacts. They resulted in multiple project participants losing homes and other assets–and having their lives disrupted to the extent that participation in the project became, understandably, impossible. This was especially true for the community in Wairewa who were severely and directly impacted–and also for various other project participants.

A large proportion (8000HA or 40%) of the project's Reference area was directly burnt, some of it at high severity. Around 7000HA or about 18% of the project's Treatment area was also directly impacted.

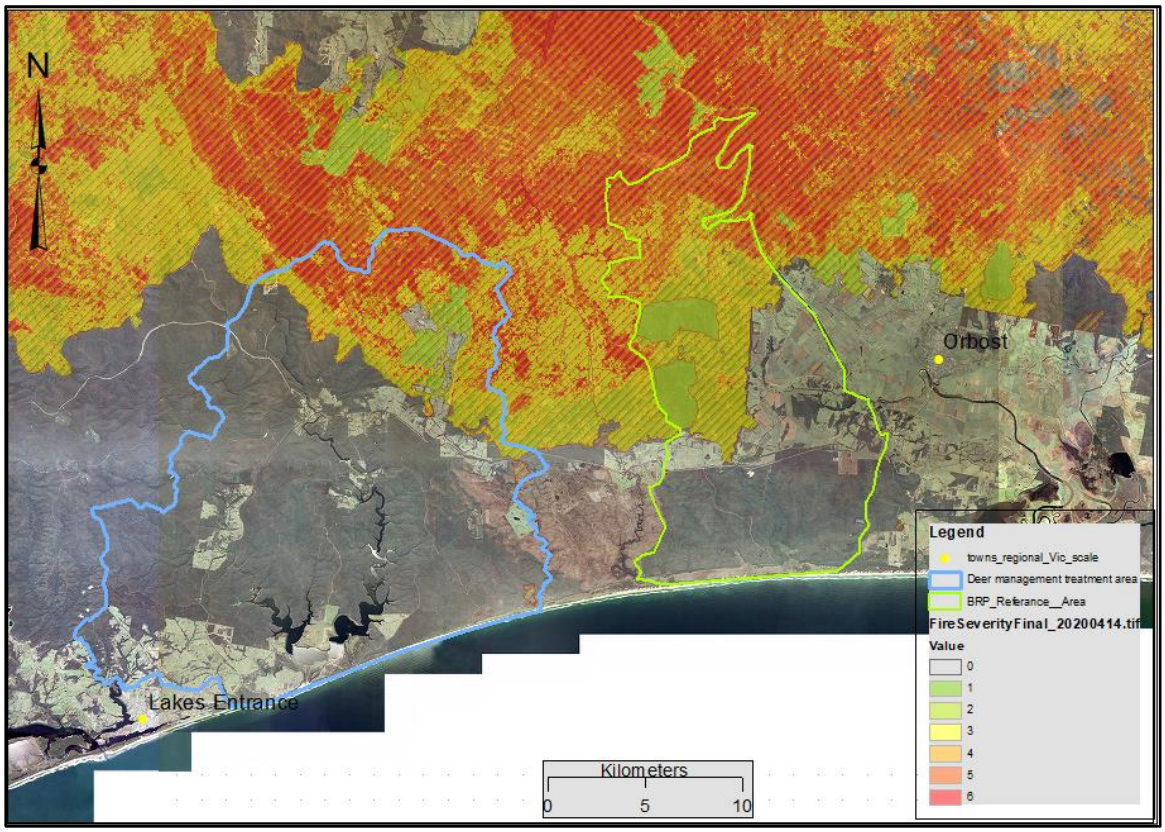


FIGURE 35: DEER PROJECT AREAS AND 2019/20 FIRE SEVERITY

Loss of ground cover and understory vegetation was entire in some areas, with the fires directly killing an unknown number of deer. Local residents reported mass mortality of deer, among other animals. The fires also likely forced the migration of many deer and a general reorganization of the deer population, both within and around the fire footprint. The overall

impact of the fire on project overall outcomes remains unknown, but the impacts are believed to be significant.

Covid-19

The global covid-19 corona-virus pandemic and subsequent 'lockdowns' started in April 2020, around 10 months into project delivery. There was complete cessation of officially sanctioned hunting activities across the project area for almost half of the project, and lockdowns continued to varying extents throughout the project. The reduction in the project's capacity to collectively meet and organise, as well as hunters' ability to visit landowners or hunt within the project area caused highly significant impacts on project delivery. The impacts of the covid-19 pandemic on overall project outcomes are hard to quantify but were profoundly disruptive.

Drought

The breaking of the drought also presented significant challenges to the project's ability to relate changes in vegetation to our management intervention. This was due to the phenomenal ecological release and growth rates brought about by significantly above average moisture availability.

FIGURE 36: GUNAIKURNAI TRADITIONAL OWNERS INSPECT DEER RINGBARKING OF RAINFOREST TREES

Conclusion

Littoral Rainforest is a highly specialised vegetation community, which remains critically endangered and threatened by Sambar deer. Consequently, it is important that management interventions for deer population control continue to progress. These controls must be acceptable to the broader community and a majority of stakeholders, and able to be applied at the landscape scale and across multiple land tenures.

This project successfully facilitated multiple project partners, including Gunaikurnai Traditional Owners. The project also developed methods to link private landowners and public land managers with accredited volunteer hunters to deliver coordinated deer control across multiple land tenures. Refining processes that can lead to ongoing deer control activities beyond the lifetime of this project.

This project's 'partnership-based approach' successfully engaged with and coordinated the volunteer recreational hunting community and professional contractors to deliver cross-tenure deer control activities at a landscape scale. This partnership-based approach facilitated the removal of over 1000 deer from the project Treatment area over the life of the project.

The broader East Gippsland community gained an increased awareness and understanding of the need for deer control, and an appreciation for the partnership/cross tenure approach. Achieved through print, local radio and digital media, mailouts to residents, community meetings publicising the trial – as well as many locals actually participating in the project.

Project delivery and coordination experienced significant and profound impacts, disruption and challenges. The first of these impacts came from the Black Summer 2019/20 bushfires, after only 5 months. The bushfires had unknown but likely significant implications for the deer population(s), their abundance, distribution and subsequent interactions with vegetation across the project area.

The bushfires were immediately followed by the impediments of lock-downs caused by covid-19 throughout the remainder of the project's two and a half years. These impacts significantly reduced the hunting effort and project managers' and partners capacity to collectively

organise control activities. This meant a reduction in capacity to deliver the project's activities as initially intended and ultimately compromised project outcomes.

However, despite the various challenges, camera trap monitoring data showed a greater reduction in deer relative abundance in the Treatment area, where hunting pressure was deliberately elevated, compared to the Reference area, where it was not.

While monitoring results are complex to interpret (and this work is on-going), the hunting pressure applied and its apparent influence on deer, means these methods show promise in being able to bring about population control through time.

While not conclusive (and in some instances counter intuitive) the results observed show regeneration of vegetation stabilised where deer control activities occurred and its relative decline where they had not. This suggests these control methods are likely able to facilitate vegetation regeneration and induce positive change in threatened environmental values at scales beyond the site level.

We conclude that our hypothesis – coordinated hunting as a management intervention can reduce deer abundance and improve vegetation condition at scale – is partly supported, but also somewhat confounded by our results. Our hypothesis requires further refinement and testing in order to provide robust conclusions.

We maintain that the partnership driven cross-tenure approach taken in this project is the most likely to deliver successful reductions in landscape-scale deer impacts, that it shows long term promise and should be pursued.

We also maintain that while the goodwill of the recreational hunting community is not to be discounted, coordination of multiple landowners and hunters comes at significant cost. Therefore, improvements in hunter reporting and ongoing refinement of delivery methods are required.

Future projects would benefit from better quantifying the overall recreational hunting effort with either an increase in project coordination resourcing and effort, or reduction in overall project area. This would aid quantification of the relationship between the management

interventions and response variables. Such actions would assist the further refinement of deer control methods and the management of deer impacts which otherwise will continue to drive declines in some of our most threatened environmental assets.

Appendices

A – Joint Management Ranger Report on Sambar Deer damage. Lake Tyers
B – Example Land owner engagement letter
C1 – Information sheet for Land Owners
C2 – Information sheet for Hunters
D1 – Deer Monitoring protocol Lake Tyers Part 1- Rationale.
D2 – Deer Monitoring protocol Part 2. Field protocol
E – Camera Trap Statistical analysis
F - Deer damage statistical analysis
G – Regeneration statistical analysis
H – Structure Pole statistical analysis
I – Ground Cover statistical analysis

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