A pilot study examining the ecological and human dimensions of wild deer management, Nariel Valley Victoria

Francesca Bowman

B. Applied Science

Institute for Applied Ecology

University of Canberra ACT 2601

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Abstract

Management of wild deer populations in Australia is a contentious, vexatious issue, owing to their pluralistic status as valued game resource and introduced pest. There are estimated to be over 200,000 wild deer in Australia, with numbers expected to increase significantly as they expand their range to occupy suitable habitats. The existing wild populations directly or indirectly cause deleterious impacts on natural and agricultural systems.

This study explored the ecological and sociological aspects of wild deer management in the Nariel Valley, establishing preliminary data on wild deer abundance and ecological damage. In addition the study examined landholder attitudes toward wild deer to determine some of the factors that might influence people's attitudes, and the implications for management. The study represented an opportunity to gauge the need for a management response, and to identify management strategies that are acceptable to the residents of the Nariel Valley. Three species of deer have established wild populations in the Nariel Valley, Victoria: fallow deer (*Dama dama*), red deer (*Cervus elaphus*), and sambar deer (*Cervus unicolor*).

Preliminary data on the abundance and habitat utilisation of deer in the Nariel Valley was obtained using faecal pellet counts during May through August 2014, from 80 transects across four major Ecological Vegetation Classes (EVCs). Faecal pellet indices indicate that deer abundance is high, with deer showing some differential preferences between vegetation communities. Considerable ecological damage was observed in all four EVCs, including browsing, thrashing and trampling, antler rubbing, formation of trails and wallowing. The current visible damage raises questions about potential damage that the species will cause as the population increases.

Quantitative and qualitative data obtained from questionnaires (n=34) and interviews (n=29) showed widely varying attitudes toward deer and potential management. Of the residents in the valley, there is a higher proportion of lifestyle property owners (56%) than primary producers (44 %). Most respondents (94%) had wild deer on their property, and many (59%) reported damage caused by deer, but particularly if they were primary producers (70%). Nearly all respondents (90%) who reported damage wanted a reduced deer population, showing that there is a strong relationship between attitudes and deer damage. Preferred control methods varied considerably, however game meat harvesting (37 %) and recreational hunting (31%) were the favoured options for control.

This pilot study was based on a combination of ecological and sociological data which allowed a more complete picture of the complex wild deer management situation to be obtained. This type of integrative research is fairly innovative but necessary to address the complexities of ‘wicked’ environmental problems such as are encountered with deer management. While the ecological information is essential to provide an evidence-basis for management strategy development, it is the human perspective that determines management priorities and appropriate methodologies. Considerable engagement will be needed with all relevant stakeholders to develop an acceptable, effective management strategy. An adaptive management approach also will be required to allow for adjustment to new circumstances including increases in knowledge, environmental change and changes in community attitudes.

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Chapter 1 - Introduction

Invasive species - establishment and effects

Biological invasions can be caused by the movement of species from one bio-geographical region to another. This process can occur naturally or, as in the case of the introduced deer, by human agency. The intentional (legal and illegal) and inadvertent translocation of species to areas outside their native range from human activities has increased significantly over the last few centuries becoming a global phenomenon (Hall and Gill 2005; Vitousek *et al.* 1997).

With the European colonisation of Australia, many non-indigenous species have been intentionally introduced. These introductions occurred for a range of purposes, including: agricultural production, transport, bio-control, sport, hunting and aesthetics (Bomford and Hart 2002). Invasive alien species are strongly implicated in the loss of native biodiversity and are considered, together with habitat destruction, to be a major threat to biodiversity and a leading cause of extinctions and population decline (Allendorf and Lundquist 2003; Mack *et al.* 2000; Short and Smith 1994; Walker and Steffen 1997). In the past 200 years, Australia has gained the undesirable record of having experienced nearly half of all the known mammalian extinctions worldwide (Short and Smith 1994).

Invasive species cause considerable economic and social impacts in Australia. It has been estimated that invasive species cost the Australian people $743.5 million per year through loss of agricultural production, including horticulture, and the expenditures on management, administration and research (Gong *et al.* 2009). This estimate does not account for environmental and all control costs and is therefore said to be an underestimate of the true impact of invasive species in Australia (Gong *et al.* 2009).

Because of the significant economic, social and environmental threats posed by invasive species, the mitigation and the remediation of their adverse impacts is an important component of conservation management (Hobbs and Norton 1996; Zavaleta *et al.* 2001).

Species background

During the late nineteenth and early twentieth century, 18 species of deer were deliberately introduced into Australia (Bentley 1978). Of the 18 liberated deer species, the majority (12) failed to become established and went regionally extinct. Only 6 species were successful in establishing viable wild populations (Bentley 1978; Moriarty 2004).

Introductions occurred as a result of acclimatisation societies, which promoted the establishment of wild deer populations for aesthetic and game purposes (Long 2003; Moriarty 2004; Rolls 1969). Following their establishment, deer were mainly hunted for food and sport and enjoyed for their aesthetic value (Jesser 2005). The initial introductions, coupled with escapes and releases from deer farms and illegal translocations, have assisted in the establishment of wild deer populations in the Australian environment (Moriarty 2004).

All six species of introduced deer have established wild populations in Victoria, with well-established and widespread populations of sambar deer (*Cervus unicolor*), fallow deer (*Dama dama*) and red deer (*Cervus elaphus*). Chital deer (*Axis axis*), hog deer (*Axis porcinus*) and rusa deer (*Cervus timorensis*) exist in smaller isolated populations (Bentley 1998).

Collectively, all six species occupy a variety of habitats, ranging from arid woodland to rainforests (Moriarty 2004) (Figure 1.1). However bioclimatic modelling suggests that they do not currently occupy all suitable habitats and that there is still 'immense scope to expand their distributions in Australia' (Moriarty 2004, p. 296). The geographic ranges of all six deer species are continuing to increase through both the expansion of existing populations into new regions and from the establishment of new populations as a result of illegal translocations (Moriarty 2004).

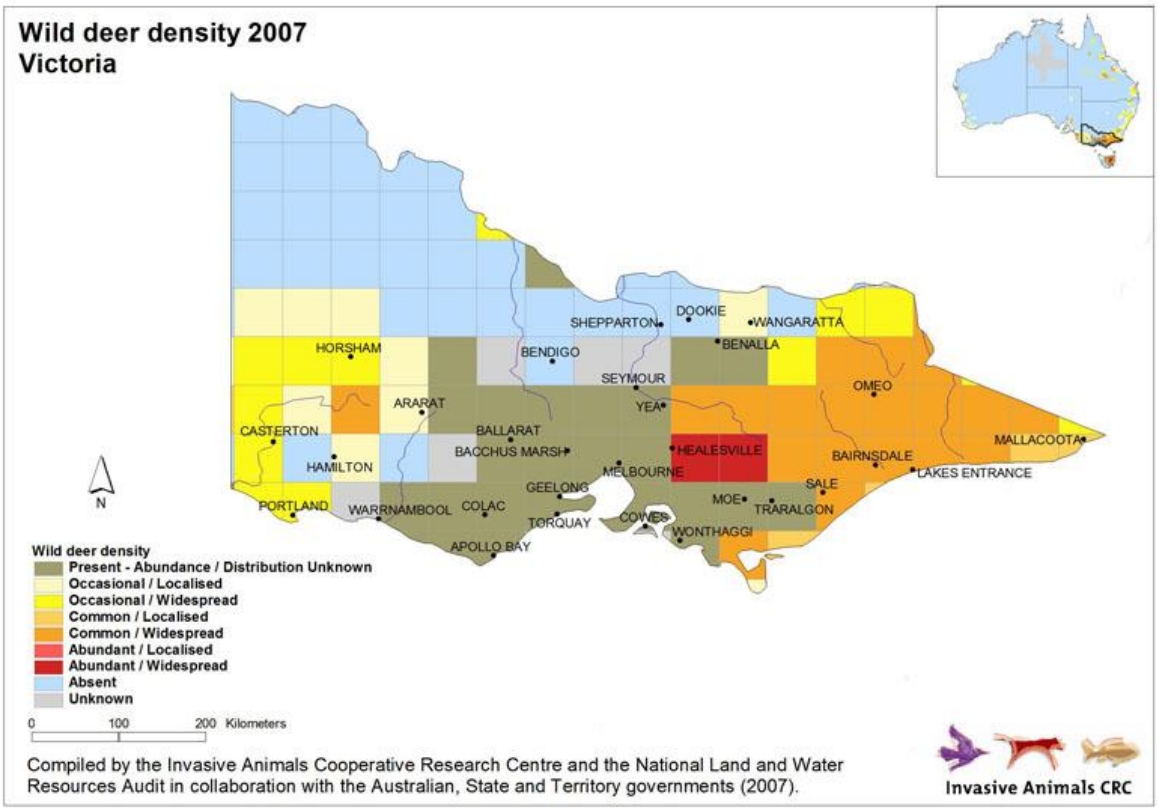

Figure 1.1 Map of deer density and distribution across Victoria in 2007. Source: Invasive Animals CRC (2014).

Such an increase in abundance and range expansion presents concern to conservationists and land managers as numerous scientific studies have identified adverse environmental impacts associated with wild deer. These impacts include: loss of plant biodiversity and biomass from overgrazing and browsing; physical damage such as trampling, ring-barking, thrashing and antler rubbing; facilitation of invaders such as dispersal of weeds; and other environmental degradation and ecosystem impacts through the creation of trails, concentration of nutrients, erosion and degradation of water quality (Bennett and Coulson 2011; Bilney 2013; Jesser 2005; Keith and Pellow 2005; Peel *et al.* 2005).

Additionally, populations of wild deer have the potential to cause significant impacts on primary production. Numerous direct and indirect impacts to agricultural systems were identified by Lindeman and Forsyth (2008), including: damage to infrastructure such as fences and netting; damage to agricultural crops from grazing and trampling; damage to forestry plantations including browsing, bark stripping and antler rubbing; damage to orchards including eating of fruit crops, stripping bark, breaking branches and rubbing of trees; and general impacts including weed dispersal, creation of trails and fouling of water

holes. In this same study, it was estimated that the average cost to producers was $4600 annually but ranged from anywhere between $200 and $20 000 depending on the size and nature of the agricultural operation and its proximity to habitat that supports deer populations.

Another concern is that deer have the potential to carry diseases that could be transmittable to livestock (Jesser 2005). Deer are biologically similar to other domesticated ungulates and they are susceptible to the same parasites and diseases such as cattle tick, leptospirosis, Johnnes disease, malignant catarrhal fever (MCF) etc. Disease management agencies and landholders are concerned that deer could act as a potential vector for a range of diseases and parasites which could be introduced into domestic stock populations causing impacts on production (Brown 2010; Jesser 2005). In the event of an outbreak of a disease, and given that deer typically inhabit forested environments, a reduction of infected populations would be difficult to achieve. Subsequent control of the disease would be problematic and would lead to significant costs associated with control (Jesser 2005).

This increased understanding and awareness regarding impacts associated with wild deer has prompted government agencies to formally recognise the threats posed by wild deer. In recognition of these impacts, sambar deer have been listed in the Victorian *Flora and Fauna Guarantee Act 1988* as a 'Potentially Threatening Process' due to their ability to alter the environment through the reduction in biodiversity of native vegetation.

However, despite such growing concern regarding ecological impacts, deer remain among the least studied mammal species in Australia. In particular, knowledge about the severity of the impacts that deer inflict on the Australian environment is still limited and poorly understood (Bennett 2008; Bennett and Coulson 2011; Bilney 2013). Because of these knowledge limitations, many people within the community strongly contest the notion that deer cause significant environmental damage in Australia (Bentley 1998).

Incomplete understanding of impacts associated with exotic animals is known to exacerbate conflicts (White and Ward 2010) and can lead to conflicted management priorities. In Victoria, deer are partially protected by State legislation that classifies them as 'wildlife' for the purposes of the *Wildlife Act 1975* (the Act) and further listed as 'game'. This legislation recognises deer as a valuable game hunting resource. Deer are managed to 'provide continued, sustainable hunting opportunities' (Game Management Authority 2014). This gives deer partial or full protection in order to maintain wild populations for recreational hunting (Finch and Baxter 2007).

However, other legislation (i.e. *Flora and Fauna Guarantee Act 1988* (Vic)) recognises their destructive capacity on the natural environment. The nature of such management dilemmas and the competing demands and incompatible objectives of different stakeholder groups has created a situation in which deer management has become a '*wicked'* problem where no management solution will be able to satisfy all factions (Nugent and Fraser 1993).

Despite the negative impacts some introduced species have on the environment, many are valued for the perceived economic and social benefits that they provide (Kendle and Rose 2000). Recreational hunting of wild deer generates significant economic benefits for the state of Victoria. A recent study estimated $439 million was generated in Victoria during 2013 from hunting pest and game animals (Morison *et al.* 2014). In 2013, there were around 27,000 licensed deer hunters, who reportedly contributed approximately $57 million to the Victorian economy through deer hunting activities (Game Management Authority 2014). As a result, the Victorian Government has identified recreational hunting as an important contributor to the state's economy (Morison *et al.* 2014).

From a strictly economic point of view, this is seen as being beneficial; however there has been no attempt to quantify the environmental and social costs that are being incurred in the process of this economic activity. This is similar to the reasoning that supports other extractive industries and activities as being economically advantageous with no wider consideration of costs. This paradigm blindness limits the debate of costs and benefits and contributes to the challenge of developing an appropriate management strategy.

Biology

It is important to have an understanding of the biology and ecology of deer species to better inform management (Braysher *et al.* 2011; Hall and Gill 2005). The six species of deer in Victoria originate from Eurasia and the Americas (Van Dyck 2008). Whilst each species has unique characteristics, is adapted to different environmental conditions and has specific habitat and dietary requirements, they generally share similar physiological characteristics and behavioural traits (Bentley 1998; Clarke 2000). General characteristics include:

Dietary requirements

Deer are ruminants; this system of digestion enables deer to consume and obtain nutrients from a wide variety of plant species including low quality forage such as coarse vegetation including grasses, herbs, shrubs, berries etc. (Geist 1998). Deer are classed as grazers, browsers or intermediate feeders depending on the dietary preferences of each species. Most species are generalist herbivores/dietary opportunists, which can utilise a wide range of plants in their habitat (Geist 1998). Deer are said to prefer grasses but are known to browse opportunistically on buds, shoots and leaves of trees, shrubs and herbs (Bentley 1978; Keith and Pellow 2005). Deer typically browse on the lowest 2 m tier of forests (Husheer *et al.* 2003). The ability of deer to feed on the wide range of vegetation across the diverse landscapes of Australia demonstrates the remarkable adaptive capacity of these species.

Behaviour

Deer are generally nocturnal and/or crespucular, with a peak of activity occurring at dawn and dusk, and tend to rest in dense vegetation during the day (Bentley 1978). Social organisation among deer species is complex. Some species of deer are largely solitary, such as sambar and hog deer. This is thought to be an adaptation to living in habitats consisting of dense and structurally complex vegetation. However, most species tend to be gregarious, forming herds for a part of the year which range from a few individuals to a hundred or more. These tend to be deer which are more adapted to open habitats (Van Dyck 2008). There is limited knowledge regarding the home range sizes and seasonal movements of the deer in Victoria (Lindeman and Forsyth 2008).

Deer are polygamous, with stags competing for the control of a group of hinds during the breeding season. Competition between stags is aggressive and involves physical contact with their antlers, which is known as 'rut' (Jesser 2005). Antlers are also used for territorial behaviour such as marking and thrashing vegetation and for intimidation of rival males (Van Dyck 2008). Stags rub their antlers on trees to remove velvet from fully grown antlers; they also rub for scent marking to define territories by rubbing a waxy pungent secretion omitted from a preorbital gland onto trees and other objects (Jesser 2005). The results of this behaviour can be observed by patches of bark removed from trees. It has been suggested stags may also rub their antlers on trees as a mechanism to strengthen muscles in preparation for fighting during the mating season (Bentley 1978).

Population demographics

Deer have a high replacement potential due to their relatively high fecundity and long breeding lives (Asher 2011).The maximum annual population growth rates (r_m) calculated by Hone *et al.* (2010) range from 0.45 – 0.76 for the known deer species in Australia. The corresponding maximum annual proportion that would need to be removed to stop population growth ranges from 0.34 - 0.49. This indicates that wild deer, in the absence of regulating factors such as predation, competition, and nutritional restrictions, have the capacity to rapidly increase their populations.

In Australia, wild deer have few predators, which add to their potential for rapid population growth. Dingoes, wild dogs (Bentley 1998) and wedge-tailed eagles (Rattray pers, comm. as cited in Bennett 2008) are the only species that are known to occasionally predate on weak and/or vulnerable individuals such as calves, the old, sick or injured. The only other form of population regulation through predation is by human hunters (Bentley 1998).

These traits have aided the establishment of wild deer populations in many regions of the world and as a result they are now recognised as the world's most successful invasive mammal species (by abundance) (Clout and Russell 2008).

Control

Control of deer populations in Victoria is restricted to opportunistic shooting by recreational hunters and landowners. Recreational hunters require a Victorian Game Licence which is administered by the Game Management Authority (GMA). Hunting is typically carried out by stalking the animal. Scent trailing hounds may be used to locate and track deer; however this form of hunting is restricted to certain breeds of hounds, deer species and to certain seasons. Hunting deer using spotlights is not permitted on public land, although this method is arguably the most effective method for hunting deer.

Hunting is permitted in Victoria in State forest, unoccupied Crown land, State Game Reserves, and on private land. Hunting is not permitted in sanctuaries, Melbourne Water Catchment areas, Alpine Resorts, National Parks, State Parks, Coastal Parks, Wilderness Parks, Forest Parks, Flora and Fauna Reserves and Nature Conservation Reserves (Department of Enviroment and Primary Industries 2014a).

Given the conventions of hunting, which focus on stalking animals, this form of control is ineffective because it does not reduce the wild deer populations to densities at which ecological impacts are minimised and on a scale that is warranted (Bilney 2013; Bomford and Hart 2002; Braysher 2013). While a reduction in deer populations is promoted by conservationists, it is not yet known what level of control is required to mitigate damage by deer (Keith and Pellow 2005). Whilst it is recognised that recreational hunting will not be effective as a standalone technique, little research has been conducted to assess the effectiveness and social acceptability of other methods (e.g. trapping, poisoning, contraceptive programs etc.). Recently the Victorian Government made amendments to the *Wildlife Act* creating an ‘order’, which no longer protects deer on private land. Landowners are now permitted to control ‘problem deer’, which includes the use of spotlights at night – a technique prohibited on public land. Deer are considered to be a problem if they are causing damage to crops, fences and other farm assets.

Management - Integrating the ecological and human dimensions

There is a diversity of perceptions and opinions about deer which means there is no consensus as to what should be an appropriate strategy for managing deer. As people are a major presence in and influence on landscapes, any successful attempt at managing wild deer will require the cooperation of numerous stakeholders and consideration of the diversity of views and opinions that they hold (Austin *et al.* 2013; White and Ward 2010). Good wildlife management is defined by Hall and Gill (2005) as '*the art of utilizing scientific evidence to manage human practices, perceptions and values*' (p.843). It is therefore of paramount importance to integrate the human dimension with the ecological science (García-Llorente *et al.* 2008) to maximise the efficacy of the management strategy to address this complex issue.

Incomplete understanding of impacts associated with exotic animals is known to exacerbate conflicts between stakeholders who have competing priorities (White and Ward 2010) and can lead to management processes with conflicted priorities. Wild deer populations have increased and there is a lack of adequate data on their impacts; because of this there is potential for conflicts between land managers and stakeholder groups (Austin *et al.* 2013; Moriarty 2004).

Opportunities for effective management are often compromised when there are competing value systems, attitudes and where there is minimal or non-existent cooperation from landholders (Finch and Baxter 2007; Messmer 2000). As the impacts of wild deer in Victoria are still being researched and quantified, there is no agreement or consensus among stakeholders on how they should be managed (McLeod 2005). This dichotomy makes it difficult to achieve an objective debate that will allow management based on scientific understanding combined with assessment of social values and management objectives (White *et al.* 2008).

Natural resource managers often have to contend with problems that are not easily defined. This is because stakeholders approach the situation and identify the dimensions of the problem based upon their own perspective. The definition of a problem can limit solutions because the way the problem is understood shapes the solution to it (Chapple 2005).

To resolve these conflicting arguments, a better appreciation of the impacts and stakeholder values and attitudes is required to increase our understanding of the problem and to help inform and assist management (Bennett 2008).

The human dimension of wildlife management considers how the biological and ecological understanding of a problem can be integrated with an understanding of the sociological dimensions (Miller 2003). Until recently, wildlife management research focused on the ecological processes involved and gave little attention to the human component of invasive species management (García-Llorente *et al.* 2008). However there is a growing recognition that the success of any management program to mitigate effects will be largely influenced by stakeholders. Therefore management requires a holistic approach which recognises people as a fundamental part of the management process (Dinsdale 2004; Fritts *et al.* 1997).

The integration of these disciplines is an important step in improving wildlife management (García-Llorente *et al.* 2008).This combined focus on the ecological and social science dimensions should give wildlife managers a greater chance of developing a management program that is ecologically and socially sound (Nimmo and Miller 2007).

As wild deer are present over multiple land tenures, stakeholder participation and support of management programs is needed in order to meet the objectives of any management program (Ford-Thompson 2011). Wild deer management will require active engagement with stakeholder groups to ensure that they are part of the deliberative process (White *et al.* 2008).

Effective management is hindered because there are conflicting management strategies employed over the range the species occupies. Because deer are widespread throughout south-eastern Australia (Moriarty 2004), the management strategy applied in Victoria will need to be supported by NSW land managers. This provides an additional challenge to management (Ford-Thompson 2011). The current lack of coordinated management efforts over large areas and across jurisdictions reduces the ability to effectively control deer numbers and bring them down to an ecologically desirable level (Hall and Gill 2005).

In order for management to be effective, management objectives must be consistent and land managers must work together (Hall and Gill 2005). There is an urgent need to develop effective and appropriate management strategies for wild deer in Australia. However, the limited ecological understanding of the impacts of wild deer in the Australian environment is limiting the development of an effective management strategy (Bennett 2008; Bilney 2013).

Although there are a number of control methods available, such as targeted culling and recreational hunting, no method in isolation is likely to be able to effectively control deer populations. A highly coordinated, well-funded and managed control program that is based

on best available science and a knowledge of stakeholder values and attitudes is required if this emerging issue is to be dealt with effectively.

Any successful attempt at managing wild deer will require the cooperation of many stakeholders, and a management program will need to take into account the diversity of stakeholder opinions. Therefore there is a great need to integrate the human dimension with the ecological to enhance the understanding of such complex management problems.

Aims and Objectives

The aims of this research are twofold: the study will explore the ecological and sociological aspects of deer management in the Nariel Valley, Victoria. First, the study will establish preliminary data on wild deer abundance and impacts in the valley to identify their influence on the local environment. Second, the study will examine landholder attitudes toward wild deer to determine some of the factors that influence people's attitudes, and the implications for management. The study represents an opportunity to gauge the need for a management response, and to identify management strategies that are acceptable to the community. Further, these data will constitute a baseline for monitoring deer abundance and impacts, thereby providing a foundational reference for future research.

This pilot study has the following five main objectives:

1. Determine an index of relative deer abundance and habitat use in the Nariel Valley.

2. Identify those Ecological Vegetation Communities that are most at risk from deer damage in the Nariel Valley.

3. Assess the attitudes of local landholders in the Nariel Valley toward wild deer, including their benefits and damage.

4. Determine the relationship, if any, between local landholder attitudes and perceived deer damage in the Nariel Valley.

5. Identify the options for managing deer in the valley and the likely attitude of the local stakeholders to their application.

The study represents a pilot study because to date there has been little research on deer impacts in south-eastern Australia. In addition, there are few examples in the global academic literature that encompass both the ecological and social dimensions of managing a pest species. The study therefore will provide important baseline information in both these areas and demonstrate the importance of doing so for pest species management.

CHAPTER 2 - STUDY AREA

The Nariel Valley is situated within the Nariel Creek catchment, which covers an area of approximately 980 km ^{2} (Figure 2.1**,** 147.80° E, 36.33° S). Located in north-east Victoria, the Nariel Valley comprises an upland headwater catchment of the Murray-Darling Basin. As such, it provides a critical hydrological role, supplying water for the small rural town of Corryong (population of 1200) and for water demand further downstream.

The major land-use practices within the valley comprise dryland farming, with some irrigated agriculture and lifestyle properties. The small township situated at the upper end of the valley, known as *Nariel Valley*, is approximately 34 km south of Corryong and 160 km south-east of Albury/Wodonga.

The regional terrain in the Nariel Valley consists of steep, undulating forested hills and broad alluvial flood plains. In the upper reaches, the valley is steep sided with the terrain progressively becoming more undulating further downstream. Broad alluvial floodplains occur on either side of the Nariel River channel except where the channel abuts the valley margin. The floodplains have largely been converted to cleared agricultural land.

The Nariel Valley region has a Mediterranean type climate characterised by cold wet winters and hot dry summers. The mean annual rainfall is approximately 1008.9 mm, predominantly during June to August. Mean monthly rainfall does not exceed 124 mm. Snowfalls are common above 1400 metres. Average monthly temperatures in the Nariel Valley range from 2.2°C to 29.4°C, with January and February being the hottest months (Bureau of Meterology 2014).

The Nariel Valley catchment is ecologically important, encompassing sections of the Alpine National Park, State Forest, Wabba Wilderness Park and Burbibyong Creek Reference Area. A range of Ecological Vegetation Classes (EVCs) are represented in the catchment area, including some classified as endangered or vulnerable in Victoria (Department of Environment and Priamary Industries 2014b). EVCs are the standard unit for classifying vegetation types in Victoria and are described through a combination of floristic, life form and ecological characteristics. The majority of the EVCs in the study area are classified as 'least concern' meaning that greater than 50 % of their pre-European settlement extent

remains and they have been subject to little or no degradation over most of the area (Department of Environment and Priamary Industries 2014c). The four main EVCs, by area, are Herb-Rich Foothill Forest, Heathy Dry Forest, Shrubby Dry Forest and Grassy Dry Forest.

The study area was selected because it is a relatively discrete geographic area known to support wild populations of several deer species. Furthermore, the variation of landholding types and stakeholders is fairly representative of other river valleys in north-east Victoria (Paech 2008) and may be seen as a microcosm of the broader land use patterns in regional south-eastern Australia.

The Nariel Valley has populations of sambar (*Cervus unicolor*), fallow (*Dama dama*) and red deer (*Cervus elaphus*) (see Appendix 1. for description of biology). There have been no detailed studies on deer in this area previously. Anecdotal evidence indicates that sambar and fallow deer populations are common. Anecdotal evidence suggests the relative isolation of the Nariel Valley has enabled wild deer populations to develop in a comparatively undisturbed manner.

With the exception of the Alpine National Park, Wabba Wilderness Park and the Burbibyong Creek Reference Area, most of the land within the Nariel Valley catchment is publicly owned land where recreational deer hunting is permitted (Game Management Authority 2014). Most privately owned land in the Valley borders public land where hunting is permitted. All deer species, apart from hog deer, are allowed to be destroyed on private property to limit damage caused by 'problem deer' (Game Management Authority 2014). Stalking and hound hunting is permitted in State Forest, and no bag limits apply. Hunting is permitted year round, except for hound hunting, which is restricted to April through to November and then only permitted for sambar deer (Game Management Authority 2014).

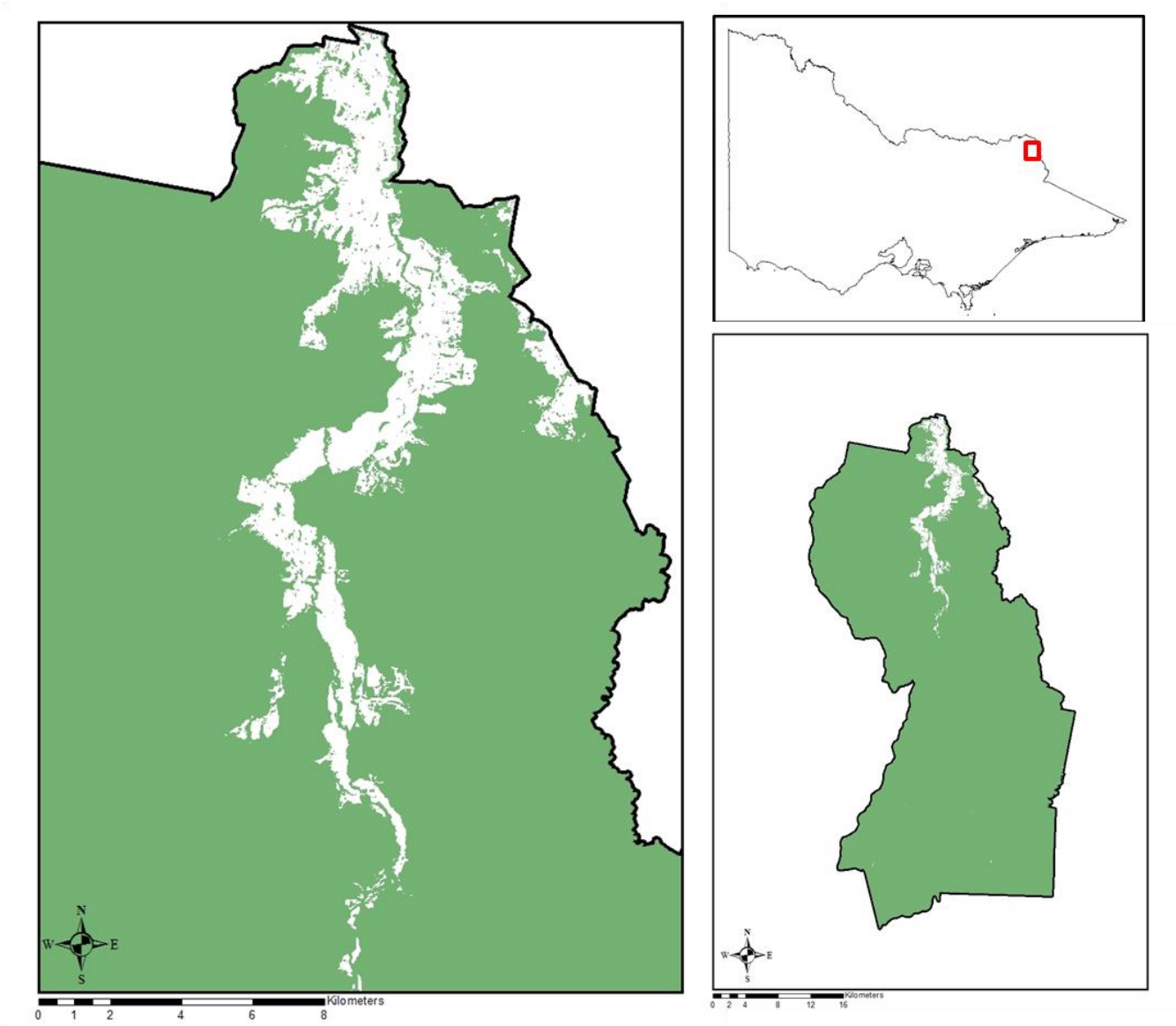

Figure 2.1 Location of Nariel Valley. The Nariel Valley is located in north-east Victoria. The catchment area is represented by green and the area that has been cleared is shown in white.

CHAPTER 3 - ECOLOGICAL RESEARCH

3.1 METHODS

As presented in Chapter 1, the main ecological aims of this thesis are to:

1. Determine an index of relative deer abundance and habitat use in the Nariel Valley.

2. Identify those Ecological Vegetation Communities that are most at risk from deer damage in the Nariel Valley.

In order to ascertain the information required to inform these aims, a series of transects were established throughout the valley and across the four main EVC's. Along these transects, plots were established, within which faecal pellet counts were conducted. Observations of impacts of deer were also recorded. Here the specific components of this research are outlined.

Faecal Pellet Surveys

Estimating the abundance of deer using direct census techniques can be difficult and problematic, especially in areas where deer are difficult to detect (e.g. forests with a thick understory) (Forsyth *et al.* 2011). Consequently, faecal pellet counts have been used as an indirect measure of relative abundance since the 1930s (Forsyth *et al.* 2011). Deer generally deposit a large amount of faecal pellets in areas where they forage (Bennett *et al.* 1940) or after a period of resting and rumination (Gunn and Irvine 2003). Deer typically defecate 10 to 20 times a day, defecating up to 100 or more pellets in clusters, which are termed 'pellet groups' in each defecation (Forsyth *et al.* 2011). Sampling of the faecal pellets can be conducted as part of a systematic stratified survey design, such as the Faecal Pellet Index (FPI) protocol (Forsyth 2005).

An index provides a 'measurable correlative of density' (Caughley 1977, p.12). Forsyth *et al.* (2007) have shown that faecal pellet counts have a positive and linear relationship with deer abundance. They thus provide a useful and reliable index of relative deer abundance as well as an indication of areas of occupancy (Bennett *et al.* 1940; Forsyth *et al.* 2007).

Whilst attempts have been made to calculate absolute abundance using faecal pellet counts, accurate estimation of deer abundance is difficult to obtain without information on the local decay rates of deer faecal pellets and on species-specific defecation rates (Caldwell 2009). There is currently a lack of reliable information on local deer defecation rates and faecal pellet decomposition rates, and it was beyond the scope of this study to attempt to estimate absolute deer abundance. It was also beyond the scope of this study to attempt an index of abundance for each of the known deer species in the study area. Therefore the following assumptions were made regarding the faecal pellet data collected:

1. Deer defecate at the same rate in different areas.
2. The decay rate of pellets is similar in different habitats within the valley.
3. The average number of pellets per pellet group is the same throughout the valley.

Differentiating the faecal pellets of sympatric deer species in the field is difficult (Forsyth *et al.* 2011), and may require genetic testing for confirmation. Nevertheless, determination of areas of occupancy and an index of abundance for 'all deer species present' will be informative about deer presence and abundance in the study area and provide baseline information for further detailed research on deer extent, abundance and impacts.

Following the FPI protocol developed by Forsyth (2005), two surveys are conducted at least two years apart. However insufficient time during this study prevented this from being undertaken. Consequently, the survey results provide preliminary estimates of local deer abundance only.

In order to assess whether deer preferentially use some areas over others in the valley, the study area was stratified according to Ecological Vegetation Classes (EVCs). Four dominant EVCs were identified in the study area based on an Arc GIS analysis of VIC MAP DATA shapefiles provided by Department of Environment and Primary Industries (Figure 3.1) (see Appendix 2. for description of EVCs).

Permission was obtained from landholders to access private property prior to commencing field work. A total of 80 transects were surveyed across the four main EVC's (Herb-Rich Foothill Forest, Heathy Dry Forest, Grassy Dry Forest and Shrubby Dry Forest) in the upper Nariel Valley, with 20 transects conducted in each EVC (Figure 3.1). Surveys were restricted to the upper section of the valley due to accessibility issues with some areas being omitted from the study, because land owner permission was not obtained, or the terrain was deemed

too steep to be safely traversed. However the vegetation in the rest of the valley is very similar and the results obtained are likely to be representative of the areas omitted.

Transects were restricted to the fringe country, which for the purpose of this study was defined as a 200 m buffer zone of any native vegetated land adjacent to cleared/pastoral land. The fringe country boundary was established by using a buffered (200 m) minimum convex polygon using Esri ArcGIS 9.3.1. These surveys were restricted to sampling in the fringe country in order to evaluate relative deer densities in country adjacent to private property, where the stakeholders interviewed in the social assessment component of this research study lived.

Information recorded for each transect included: GPS coordinates; name of EVC; date; observer name/s; plot and transect number; total number of intact pellets; and number of pellet groups.

Transects

The Faecal Pellet Protocol outlined in Forsyth (2005) was used to count faecal pellets. Each transect started at the intersection of cleared agricultural land and native vegetation, and extended upslope into the native vegetation. Random start points for 80 transects were generated using Arc GIS, and were located on ground using a map and handheld Global Positioning System. Random sampling was used to ensure that each point in the study area had the same probability of being sampled. Using transects of a fixed length (150 m) meant that each transect provided an equivalent amount of environmental information (Forsyth *et al.* 2011). Along each 150 m transect, both the number of intact pellets and the number of groups of intact pellets in circular plots of 3.14 m^2 spaced at 5 m intervals (i.e. 30 plots/transect) were counted.

At each transect start point, a peg on the running line was placed into the ground. The running-line consisted of two durable plastic tent pegs, connected by a 5 m non-stretch cord (see Appendix 3). A knot was tied in the cord, 1 m from each peg (See appendix 3). The knot at either end defined the radius of the circular plot to be searched as part of the faecal pellet counts.

With one peg in the ground, the running-line was walked out along a prescribed bearing (moving in a direction away from cleared land) until it became taut. The second peg on the opposite end of the running-line was then placed into the ground, marking a 5 metre interval.

At this interval, the knot on the rope was then used to define the area of ground that was to be searched for intact faecal pellets. The rope was then pulled gently so that the peg marking the start point was removed from the ground.

Intact pellets were defined as having no recognizable loss of material regardless of whether the pellet was cracked, partly broken, or deformed (Forsyth 2005) (see Appendix 4). Pellet groups were judged to be one or more intact pellet(s) in close proximity and assumed to be voided in the same defecation. When searching for pellets, growing vegetation and dead fern fronds were pushed aside, but the litter layer was not disturbed. Sampling did not occur when visibility was low, for example, when it was judged to be too dark to detect pellets or if it was raining. Only pellets from deer were counted.

Prior to starting each transect, the running-line was checked to ensure that the string between the pegs was 5 m long and that the plot markers (knots) were exactly 1 m from the pegs. All faecal pellet surveys were conducted during May – August 2014.

The time spent on each faecal pellet survey differed depending on the EVC and terrain. On average, each transect took approximately one hour to complete. In addition, navigation to the randomly identified start points had to be factored into the allocated time for faecal pellet surveys. In some instances, this added considerable time to the surveys.

As hunting is permitted in the study area, high visibility clothing was worn at all times during field work to ensure personal safety.

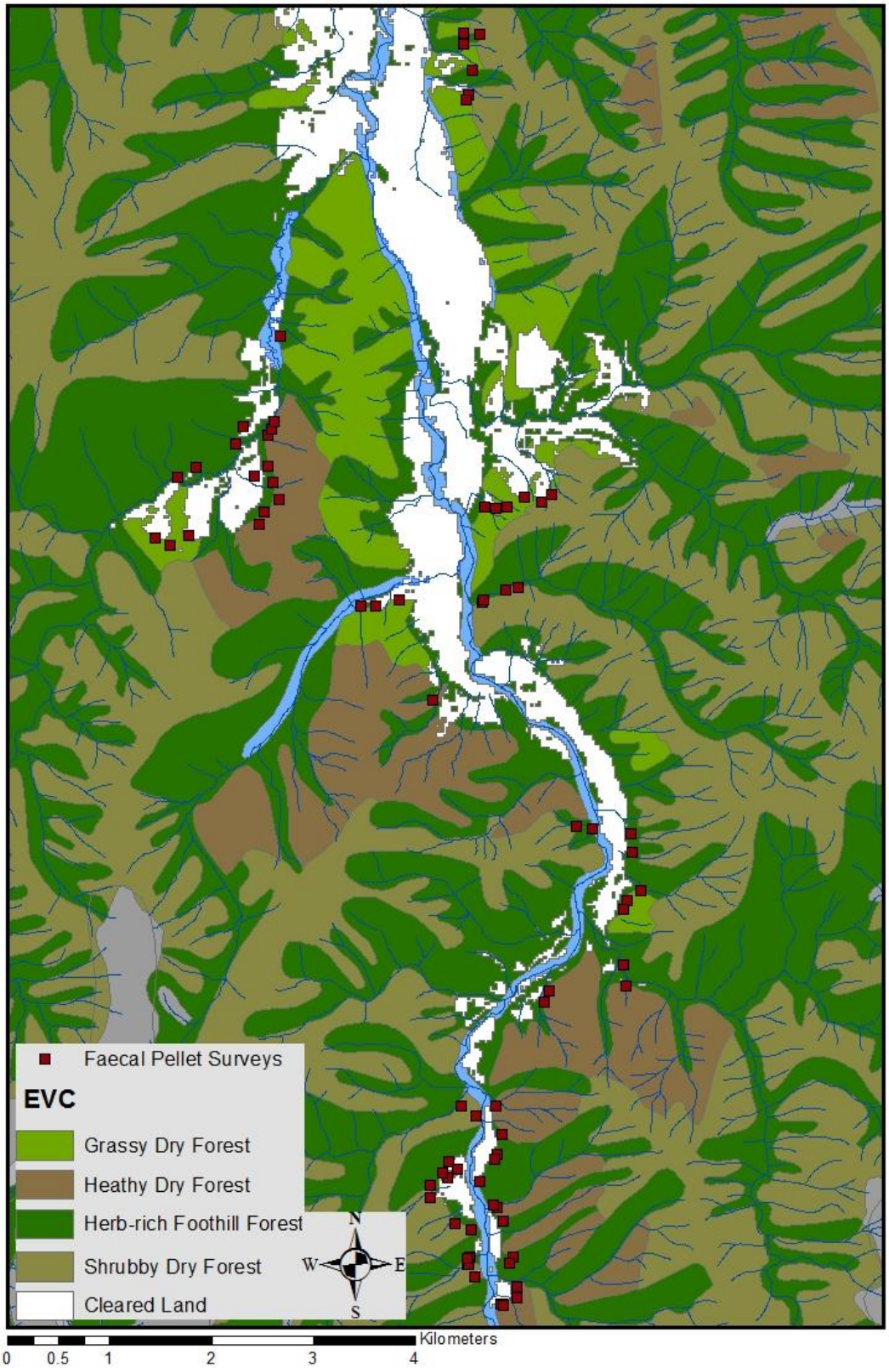

Figure 3.1 Map of study area showing the location of the faecal pellet surveys sites (*n* = 80) and their proximity to cleared agricultural land, Nariel Valley Victoria. Major drainage lines (blue linear features) and EVC's are shown (see legend).

Data Analysis

All data were entered into Excel and IBM SPSS Statistics 21 for analysis.

Faecal Pellet Index

Three faecal pellet indices categorised by EVC were calculated:

1. Mean total number of intact pellets, ± standard deviation and 95 % confidence intervals
2. Mean number of groups with >1 intact pellets (Pellet Groups), ± standard deviation and 95 % confidence intervals
3. Proportion of plots with >1 intact pellets (Pellet Frequency), ± standard deviation and 95 % confidence intervals.

These three indices have previously been used to estimate changes in the abundance of deer in Australia and New Zealand (Forsyth *et al.* 2007).

Site Occupancy

The data analysis closely followed the methods of Bennett (2011) to allow for direct comparison of results from the two studies. The research by Bennett (2008) provides a useful comparison of deer populations as it has the advantage of being reasonably current, employs similar methodology, and was conducted in an environment that was topographically and environmentally similar to the Nariel Valley.

Data that did not meet the assumptions necessary for a one-way ANOVA analysis were normalised using a log transformation. A one-way ANOVA, followed by a Fisher Least Significant Difference (LSD) post-hoc analysis, was employed to determine if site occupancy, represented by faecal pellet indices, was similar across the four EVCs. Significant differences were identified at the alpha = 0.05 level.

Assessment of Deer Damage

Damage to vegetation and soil from deer was estimated at each faecal pellet survey site (i.e. 20 transects per EVC, 600 plots). Each plot was searched for signs of deer damage. Evidence of deer damage was classified into the following categories: browsed vegetation, formation of trails, trampled or thrashed vegetation, hoof prints, wallows, and tree rubs. Where deer damage was detected, the category of damage observed was recorded together with the EVC type and the plot and transect numbers.

Extensive reconnaissance was also undertaken throughout the native vegetation in the vicinity of the transects to detect damage by deer to vegetation and soils. Observations were made opportunistically between May to August, 2014 and were confined to the native vegetation within 200 m distance from cleared land. Using hand-held and remote sensor cameras, photographs were taken to document the types and level of damage caused by deer activity in the Nariel Valley. Two Moultrie M-990i remote sensor cameras were set, unbaited, from May through August.

Note: Whilst it is understood that measuring impacts is difficult in environments where sympatric mammalian herbivores co-exist, the data collected from this research are treated as preliminary and have been interpreted with caution.

Data Analysis

The frequency of deer damage was calculated according to the proportion of plots on each transect with damage observed (categorised by EVC). This was calculated per transect and expressed as a percentage. Differences in frequency of damage categorised by EVC were analysed using a one-way ANOVA and Fischer's Least Significant Difference post-hoc analysis.

The category of damage that was observed most frequently in the study area was calculated by dividing the total proportion of each damage type across the whole study area, by the total number of plots (n= 600), and expressing the result as a percentage.

RESULTS

Faecal Pellet Indices

To investigate the relative abundance of wild deer, three indices of faecal pellet counts were calculated: total pellet counts, pellet group counts, and pellet frequency. Three measures (mean, SD, 95% CI) were calculated to assess the accuracy of each index (Table 3.1). Pellet counts of all three indices displayed a high variation in the 95 % confidence intervals, with 'pellet group' counts displaying the least variation (Table 3.1). This shows that the 'pellet group' counts are the more precise index of abundance.

Table 3.1 The mean, standard deviation and 95 % confidence intervals for total pellet, pellet group and pellet frequency stratified by EVC.

	Total pellets			**Pellet groups**			**Pellet frequency**		
EVC*	$\tilde{x}$	**SD**	**95 % CI**	$\tilde{x}$	**SD**	**95 % CI**	$\tilde{x}$	**SD**	**95% CI**
Herb Rich Foothill Forest	235.8	110.0	184.4 - 287.3	16.4	4.5	14.3 – 18.6	42.1	9.6	37.6 – 46.7
Heathy Dry Forest	226.7	140.2	161.1 - 292.3	17.5	7.7	14.0 – 21.2	43.5	14.8	36.5 – 50.4
Grassy Dry Forest	203.5	172.1	123.0 - 284.1	13.6	9.1	9.4 – 17.9	28.6	18.1	20.1 – 37.1
Shrubby Dry Forest	120.4	130.1	59.5 - 181.3	10.5	7.6	7.0 – 14.0	35.8	19.2	26.8 – 44.8

*Ecological Vegetation Class

Site Occupancy

Total pellet counts, pellet group counts, and pellet frequency were used to investigate site occupancy by wild deer. Estimates were expected to be similar in all three indices if each index gave accurate results. All three indices (Figures 3.2, 3.3 & 3.4) displayed similar results and trends showing that the indices provided reliable measures of site occupancy.

Total faecal pellet counts were normalised by a log transformation. When total pellet counts were categorised by EVC, an ANOVA revealed significant differences between groups ($F_{3, 76} = 3.57$, $p = < 0.03$) (Figure 3.2).

The Fisher's least significant difference (LSD) post hoc test showed that Herb-Rich Foothill Forest and Heathy Dry Forest had a significantly higher mean number of total pellets than Shrubby Dry Forest per m^2 ($p = < 0.05$). There was no significant difference in total pellet counts among the other EVCs (Figure 3.2).

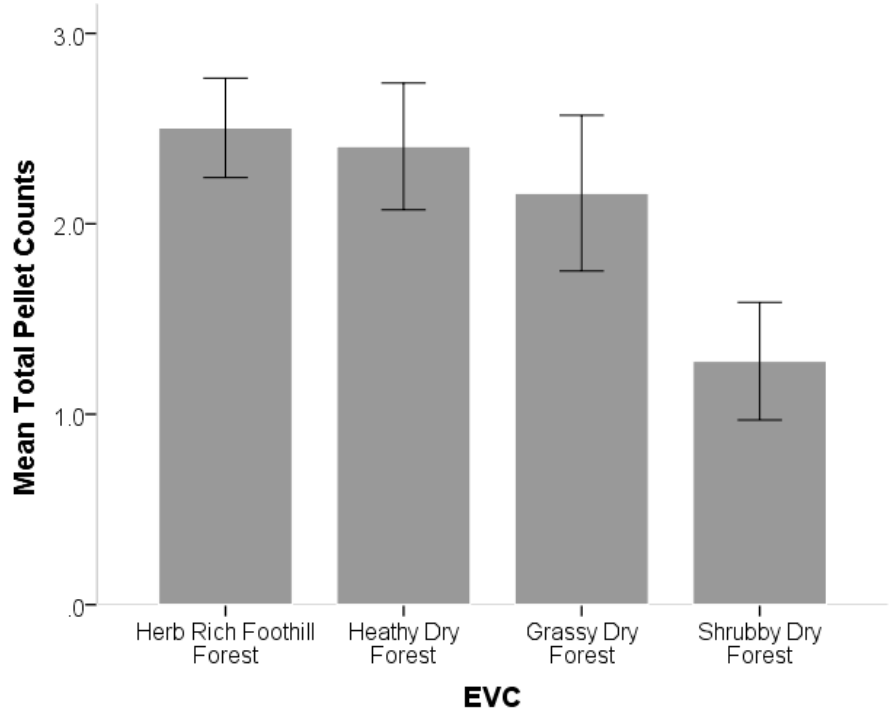

Figure 3.2 Mean total pellets per m^{-2} (± standard error) categorised by Ecological Vegetation Class (EVC).

When pellet group counts (FPGs) were categorised by EVC, and normalised by a log transformation, an ANOVA revealed significant differences between groups ($F_{3, 76} = 4.043$, $p = 0.010$) (Figure 3.3).

Fisher's LSD post hoc test showed that Herb-Rich Foothill Forest and Heathy Dry Forest had a significantly higher mean number of FPGs than Shrubby Dry Forest ($p = < 0.05$) (Figure 3.3). Grassy Dry Forest was not significantly different to the other EVC groups (Figure 3.3).

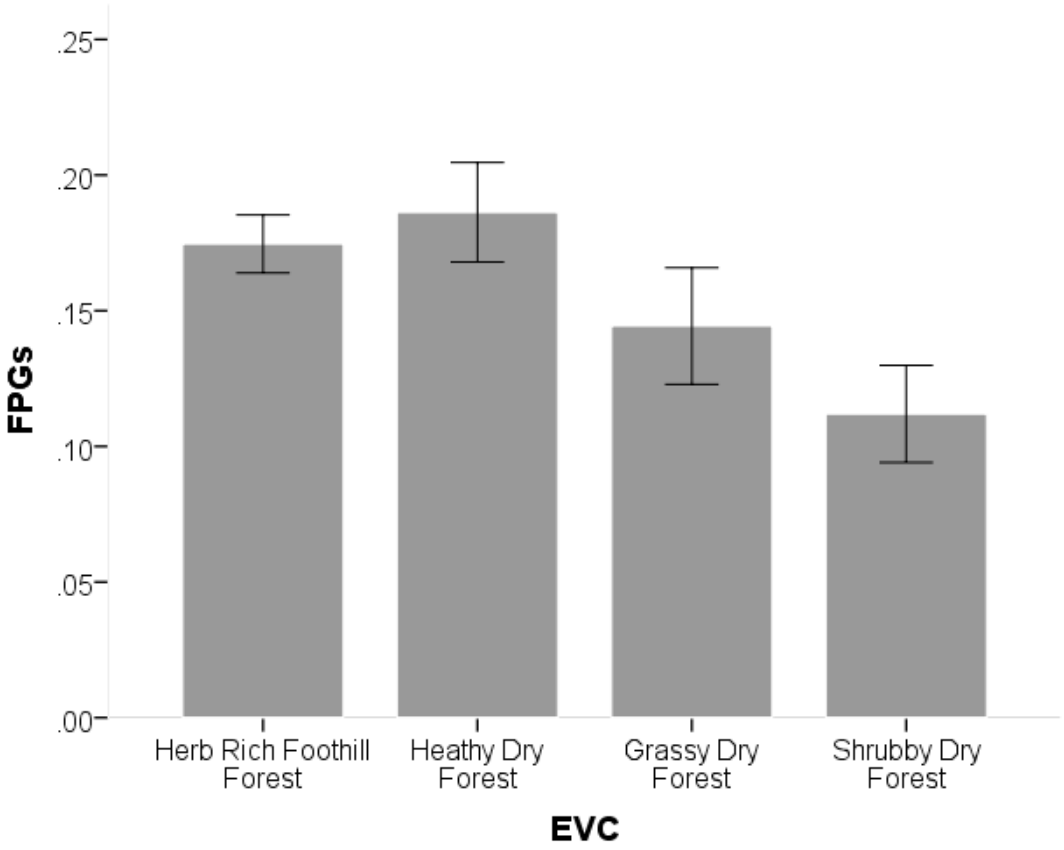

Figure 3.3 Mean number of faecal pellet groups per m^{-2} (± standard error) categorised by Ecological Vegetation Class (EVC).

There were also significant differences between EVCs ($F_{3, 76} = 3.640$, $p = 0$ .016) revealed by an ANOVA analysis of the frequency (presence or absence) of faecal pellets for each survey plot on each complete transect as categorised by EVC and expressed as a percentage (Figure 3.4).

The Fisher's LSD post-hoc test showed that Herb Rich Foothill Forest and Heathy Dry Forest had a significantly higher proportion of plots with faecal pellets than Shrubby Dry Forest ($p = < 0.05$). There was no significant difference in pellet frequency among the other EVCs (Figure 3.4).

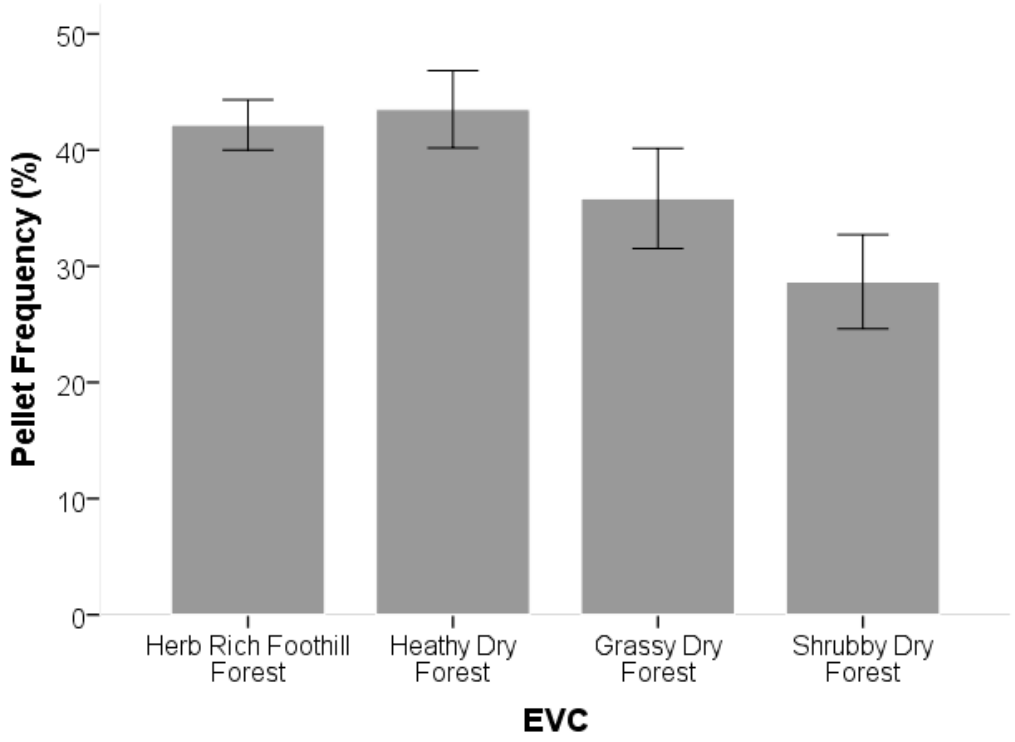

Figure 3.4 Frequency of faecal pellets (± standard error) categorised by Ecological Vegetation Class (EVC).

Deer Damage Surveys

To investigate damage to the vegetation and local environment by wild deer, observations of damage were recorded in each survey plot (n= 30), on each complete transect (n = 80) and calculated and expressed as a percentage (Figure 3.5). When frequency of damage was categorised by EVC, an ANOVA revealed a significant difference between groups ($F_{3, 76}$ = 3.640, p = 0.016).

The Fisher's LSD post hoc test showed that Herb-Rich Foothill Forest had a significantly higher frequency of damage compared with Shrubby Dry Forest (p = < 0.006) and Grassy Dry Forest (p = < 0.001). Heathy Dry Forest also exhibited a significantly higher frequency of damage compared with Grassy Dry Forest (p = 0.24).

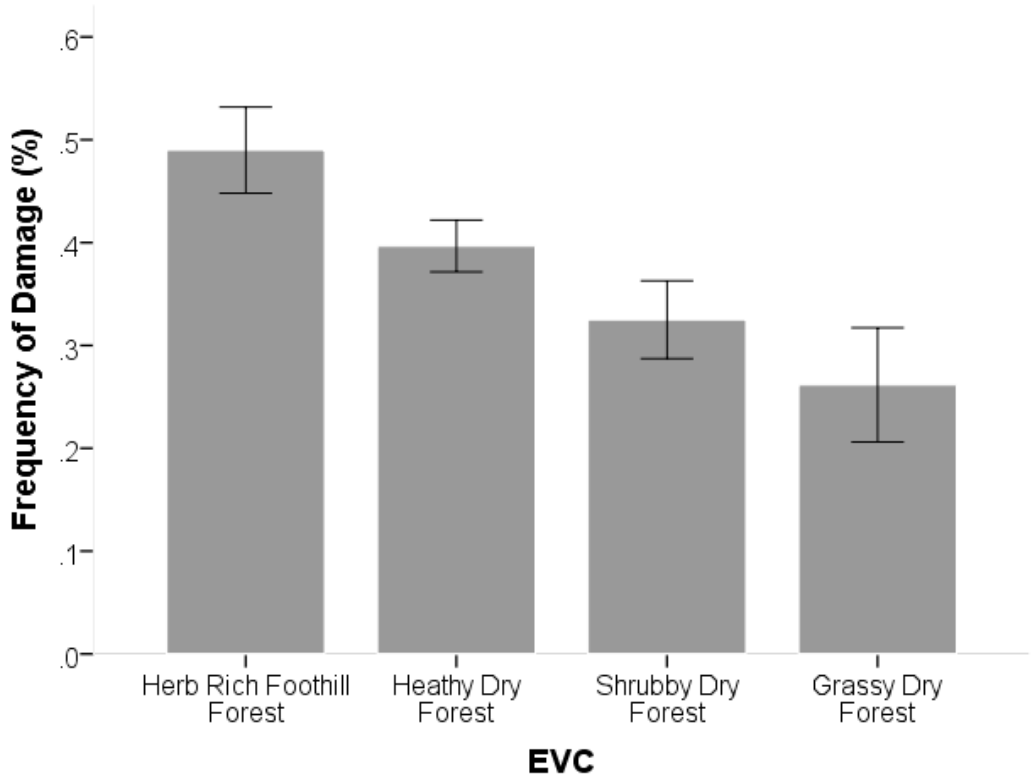

Figure 3.5 Frequency of observed damage expressed as a percentage (± standard error) categorised by Ecological Vegetation Class (EVC).

Presence of damage across all EVCs was calculated and expressed as a percentage for the whole study area. The most common category of damage was hoof prints (38 % of the plots), followed by trails (30 %) and browsing (27 %). Damage from thrashing or trampling and antler rubbing was rarely observed within the plots (Figure 3.6) but was seen in the study area.

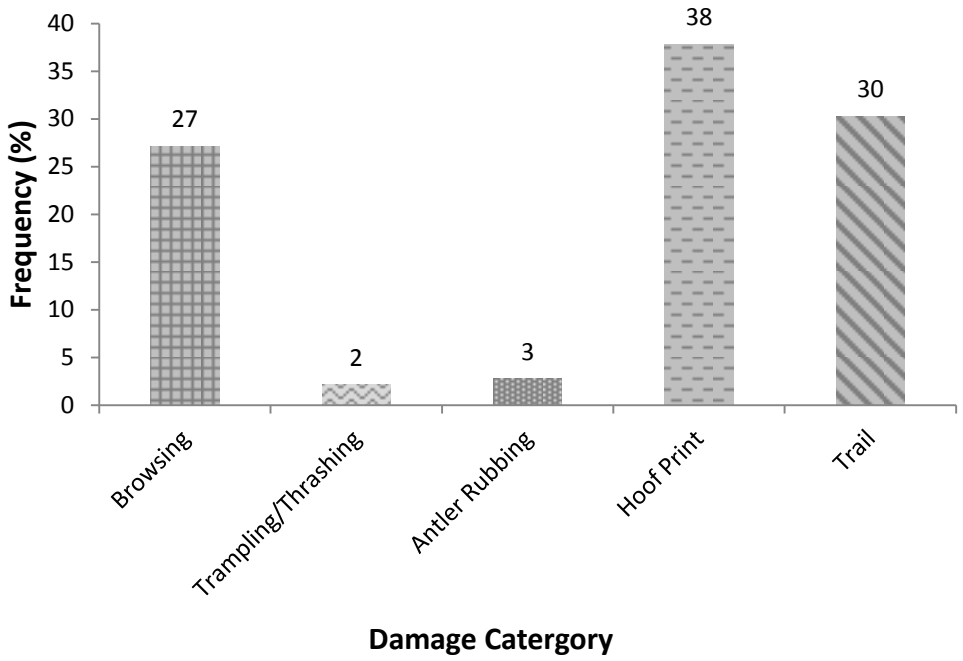

Figure 3.6 Frequency of damage expressed as a percentage, categorised by damage category.

Qualitative Observations of Damage to Vegetation and Soils

Extensive exploration of bushland surrounding farmland in the Nariel Valley was conducted in concurrence with faecal pellet counts to observe damage by deer to vegetation and soils. During the reconnaissance of bushland, five types of deer damage were noted: tree rubs (Figure 3.7); trails, scrapes and hoof tracks (Figure 3.8); wallows (Figure 3.9); thrashing and trampling (Figure 3.10); and browsing (3.11). The types and amount of damage observed within the study area suggest that structural changes in the vegetation, including trails and opened up areas, may be occurring due to deer access and activity.

Antler rubbing

Antler damage to the bark of trees and saplings was observed throughout the study area. In particular, it was common to observe removal, damage and scattered remains of bark at the base of trees, which appeared to be related to damage caused by antler rubbing. Sambar stags use this activity as a means of marking territory and toughening antlers as the antlers shift from soft velvet form to hard antler. Images taken by remote sensor camera during the study showed deer present at tree rubs (Figure 3.7) which further supports this conclusion. Antler rubbing was found to be extensive within the forest and woodland areas, with damage to some trees and saplings so significant that it had resulted in mortality of some individual plants, particularly saplings.

Antler rubbing was observed on a variety of tree species and of varying sizes in the study area (Figure 3.8). Damage was frequently observed on Cherry Ballart (*Exocarpus cupressiformis*) and Brittle Gum (*Eucalyptus mannifera*) trunks. The damage was typically concentrated at a height of 1 m, but damage was also found to extend to higher and lower heights. Often the rubbed tree had a significant trail leading to it and the ground at the base was worn in a pattern consistent with impact and compression from the hooves of deer.

Figure 3.7 A stag at a tree rub in the Nariel Valley, Victoria 2014**.** Image taken by remote sensor camera showing a stag smelling or inspecting a rubbed tree (*Eucalyptus mannifera*).

Figure 3.8 Images of antler rubbing in the Nariel Valley 2014. Antler rubbing was observed on various tree species, of varying ages and sizes (note two saplings heavily rubbed and stripped of bark).

Trails, hoof tracks and scrapes

Extensive networks of game trails were observed in the fringe country between the agricultural floodplain areas and upslope woodland, and show that there is considerable movement of animals through the area. The presence of hoof prints, deer signposts (e.g. tree rubs) and faecal pellets along these trails indicated that they were mainly used by deer. There was only a limited sign of other species using or forming the trails. Animals such as wombats, wallabies, wild dogs, cats and foxes etc. tend to use trails consistent with smaller animals and these trails tend to be low tunnels through undergrowth. In contrast, deer trails tend to be more open corridors through the bush. There were numerous trails in the study area that showed considerable amounts of deer activity, with depressions, deformation and compaction of soils by deer hoof prints frequently observed (Figure 3.9). Along deer trails, the vegetation was often trampled and worn, with bare soil exposed (Figure 3.9).

Larger denuded areas of thinned groundcover plants and exposed soils were also observed (Figure 3.9: A, D & E). Evidence suggests that these areas represented scrapes; where deer make shallow scrapes with their forefeet to mark their territory. These areas were typically observed at the base of a tree, which are known as 'preaching trees' which deer use as a territorial marker.

Figure 3.9 Trails and scrapes created by deer activity, Nariel Valley 2014. **A**. A scrape beneath a preaching tree **B.** Well-worn trail through Herb-rich foothill forest **C**. Worn section of trail, in a switch-back formation, leading down a steep hillside to cleared agricultural land **D.** Muddy ground pugged by deer hoofs **E.** A scrape exposing bare ground **F.** Deer trail leading to a watering hole **G.** Worn trail with exposed soils and reduced vegetation **H.** A deer trail leading from bushland, into fenced off agricultural land.

Wallows

Deer activity was evident also through the presence of wallows which were observed in the study area in forest and adjacent to some landholders' properties. Wallowing areas were of varying sizes and tended to be completely denuded of understory and ground-cover vegetation around shallow, muddy water-filled depressions (Figure 3.10). Wallows were generally observed in drainage lines or seepage areas. Images taken by remote sensor cameras (Figure 3.11) in the study area revealed that there was a high level of male deer activity occurring at wallows.

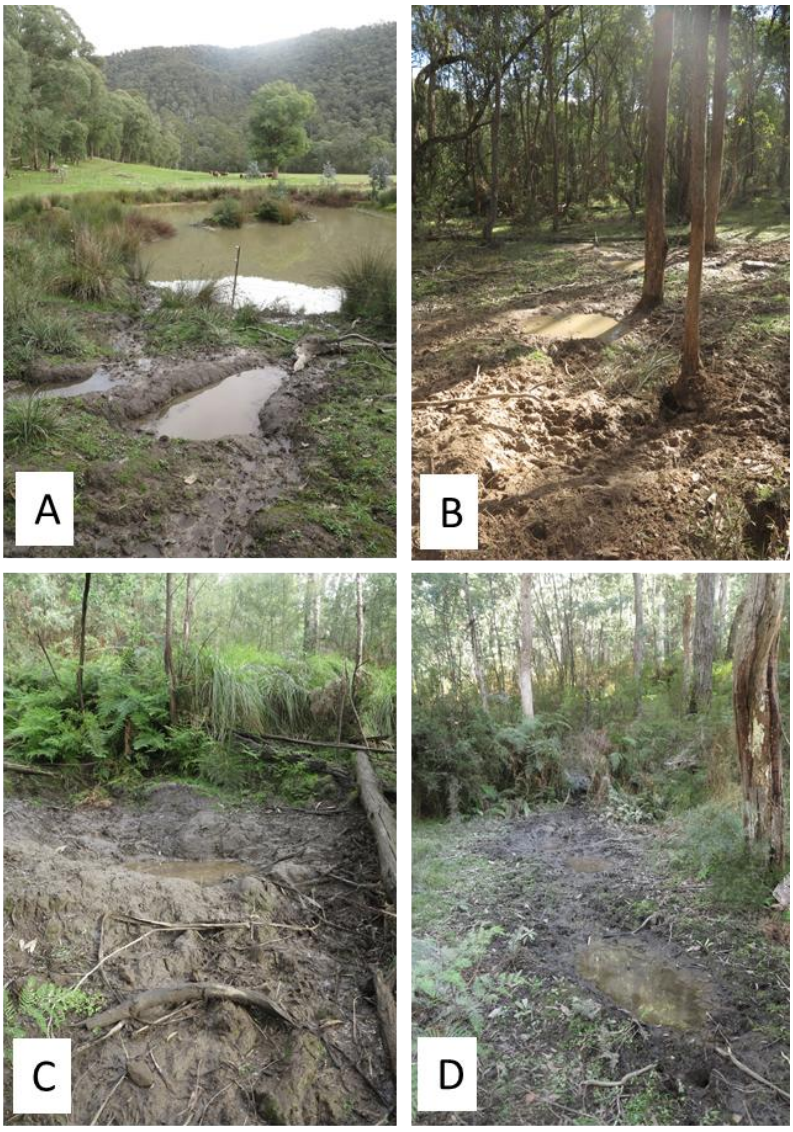

Figure 3.10 Wallows used by deer in the fringe country, Nariel Valley, Victoria 2014. Images displaying the damage caused to vegetation and soils from wallowing activity by deer. **A**. Wallows created on the edge of a man-made dam, located on the perimeter of fenced off agricultural land. An example of how deer foul water holes. **B.** Wallows located in a seepage area in Grassy Dry Forest. **C.** Wallows located in Heathy Dry Forest in a drainage line. **D.** Wallows located in drainage line approximately 50 m up-slope from the Nariel River.

Figure 3.11 Deer activity in the wallows during May 2014, Nariel Valley, Victoria. Images taken by remote sensor cameras show a high level of male deer activity, of varying age classes, at wallowing points.

Thrashing, trampling and encampments

The presence of broken branches, and trampled and thrashed understory vegetation provided further evidence of active deer activity in the study area. Some individual plants provided visible evidence that the damage was attributable to deer activity, as there was often mud and deer hair on the broken branches (Figure 3.12: F). Some areas of large-scale trampling and thrashing were observed, indicating aggressive behaviour by deer during the rut (Figure 3.12: E). Some damage caused by thrashing had resulted in plant mortality (Figure 3.12: H & J).

Open areas with lower densities of shrubs and groundcover than the surrounding vegetation were observed (Figure 3.12). The presence of faecal pellets, hoof tracks and beds (i.e. smooth ground where deer have visibly rested Figure 3.12: B) suggests that these areas function as deer camps, where deer rest and ruminate for periods during the day or evening.

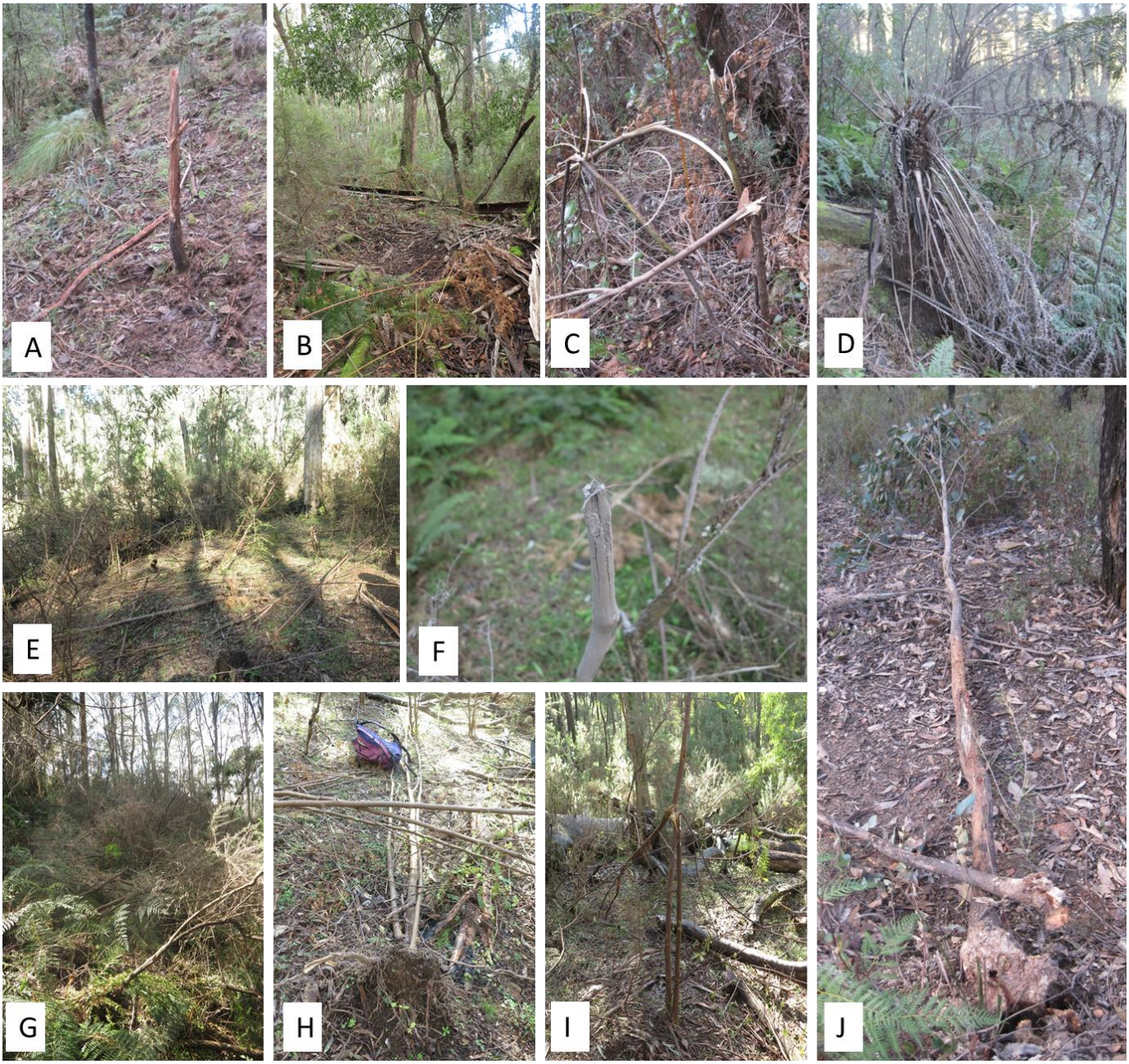

Figure 3.12 Thrashing and trampling of vegetation due to deer activity in the fringe country, Nariel Valley, Victoria 2014. Images depicting the extent and severity of damage caused by trampling and thrashing. **A.** Tree snapped in two from excessive rubbing **B.** Trampled vegetation and exposed soil, indicating a deer encampment. **C.** A young sapling damaged from thrashing **D.** A tree fern stripped of fern fronds from repeated thrashing/rubbing **E.** A large area of understorey thrashed and trampled **F.** Mud and deer hair on a plant killed from excessive rubbing **G.** Thrashed and trampled understory vegetation on a hill slope leading into a gully **H.** A plant pushed over, with roots exposed **I.** An immature tree snapped in two **J.** An immature *Eucalyptus* pushed over due to excessive/vigorous rubbing.

Browsing

Browsing damage included the removal of stems, shoots and leaves from smaller shrubs and trees (Figure 3.13). For a large number of plant species observed with this kind of damage, the loss of foliage was assessed as severe. Deer faecal pellets in areas of heavily browsed vegetation showed that deer herbivory was the cause of the browsing damage. A range of different plant species across all of the EVCs in the study area were observed with such browsing damage (Table 3.13).

Figure 3.13 Browsed vegetation in the Nariel Valley, 2014**.** The images show the effect of browsing on a range of plant speceis, including removal of stems, shoots and leaves.

DISCUSSION

The effective management of the damage due to wild deer requires information on population dynamics, abundance, distribution, and localised environmental impacts in order to develop and achieve targeted and specific management objectives (Marques *et al.* 2001; Morellet *et al.* 2007). The primary purpose of the ecological research component of this study was to gather baseline data on relative deer abundance, site occupancy and ecological damage in the Nariel Valley. This research provides important information for decision makers on the need to manage wild deer populations in the Nariel Valley and in other rural areas of Australia. Furthermore, the information gathered during this study can provide a reference point for future research and monitoring of the abundance of deer and the environmental impacts that they cause.

The following discussion considers the findings of the research, which assessed deer abundance, site occupancy and ecological damage due to deer. The discussion also considers the limitations of the ecological research methodology and discusses how it may have influenced the analysis or interpretation of the data.

Relative Deer Abundance (faecal pellet counts)

The aim of this part of the research was to establish an index of relative deer abundance for the Nariel Valley. An estimate of relative abundance can provide important information for the management of wildlife populations, and assist monitoring and control programs of selected species (Smart *et al.* 2004).

Using the FPI protocol developed by Forsyth (2005), three indices were used to estimate relative deer abundance: total pellet, pellet group and pellet frequency. Of the three indices calculated, the mean faecal pellet group (FPG) counts displayed the least variation in the 95% confidence interval, which suggests that FPG counts provide the most precise measure of relative abundance (Table 3.1).

An understanding of deer defecation behaviour is necessary to enable interpretation of field observations. Studies have found that the number of FPGs deposited per day, is a more consistent indicator than the number of pellets per day (Smith 1964). This was also found in

this study where there was less variability in the FPG counts, and supports that FPG counts have a higher level of precision for estimating an index of deer abundance.

In order to be able to establish some relative measure of deer abundance and to determine what the FPG counts signified in terms of relative population abundance (low, medium or high), FPG counts from this study were compared to results obtained from a study on sambar deer abundance in the Yarra Ranges National Park (YRNP) by Bennett (2008). The comparison of data from the two studies revealed that population abundance for the YRNP and the Nariel Valley were similar in forested environments (~ 0.1 – 0.2 FPGs m^2). It was suggested by Bennett (pers. comm. 2014) that if similar results were obtained for the Nariel Valley, it would indicate that the population abundance there is also "very very high".

FPG counts are not designed to provide a definite measure of the local deer abundance, but give an indication of probable deer numbers based on the number of faecal pellets. With consideration of this limitation, Bennett (2008) supplemented her FPG counts with a direct census (vantage point surveys) of deer sighted on areas of cleared land where visibility was unobstructed. These were primarily conducted when deer were most actively feeding, namely at dawn and dusk. Aggregations of up to 70 individuals were observed during these surveys, which equated to an approximate density of 200 deer per km^2. These are the highest recorded estimates for sambar deer populations internationally (Bennett 2008). It must be noted though that this estimate is probably distorted because of the high concentration of deer at an important food resource.

In the YRNP, faecal pellet surveys showed that deer were twice as abundant on the flats where vantage point surveys had been carried out compared to the forest (~0.3 – 0.4 FPGs m^2). The difference between the higher faecal pellet counts on the flats, compared to the forest, may be explained by the regular congregation of deer which graze on *improved* pasture in the flats, particularly during dawn and dusk. Nevertheless whilst forest habitats had significantly fewer faecal pellets than the open flats, the large numbers of deer recorded on the flats were only during particular times and indicate that a significant deer population primarily lives in the forested environments within the YRNP. Comparing the faecal pellet survey data of the YRNP to that of the Nariel Valley indicates that a significant deer population exists in the fringe country.

Sambar, fallow and red deer are mainly crepuscular; preferring to emerge from forest environments at dusk and dawn to feed on improved pasture. Studies have shown that distance to cleared land is a significant factor in habitat suitability for sambar deer (Bennett 2008; Yamada *et al.* 2003). Cleared country and improved pastures are important feeding areas for deer, especially if there is thick cover in close proximity to the cleared land, as it provides ideal habitat for deer, which as ruminants, require secure resting places between grazing. This may reveal why estimates within the fringe country are high. Sambar deer densities in the YRNP have been found to be highest on open grassland and in the immediate adjacent forest with a marked decrease after approximately 250 m inside the forest (Bennett 2008).

It is understood that surveys confined to high usage areas such as trails or roads may lead to a bias in the results and provide an inaccurate representation of the regional population of deer (Anderson 2001). Because this survey was confined to the fringe country – an area of up to 200 m from cleared land, it represents an area where deer are likely to concentrate as they move from the forested country to improved pasture (Schaller 2009; Semiadi *et al.* 1993). Therefore it is understood that the findings obtained as part of this study cannot be extrapolated more widely to the Nariel Valley. Further targeted surveys would need to be conducted in areas further removed from the forest margins to get a holistic picture of deer numbers. This would require significant additional work outside the scope of this study.

There have been few studies on population abundance of deer in south east Australia, thus there are little comparative data available. However the results of this and other studies (e.g. Bennett 2008; Houston 2003) demonstrate that, at the local and landscape scale, deer populations are considerable. A longitudinal study would be useful to clarify more precise estimates of deer abundance and establish their population trajectory (i.e. stable, increasing, and decreasing).

Limitations

The FPI counts from this study had wide confidence intervals relative to the mean (Table 3.1), revealing a relatively large degree of variation amongst transects and suggesting that the precision of the data is low. Fewer transects (*n*= 20) were conducted in each EVC than recommended (*n* = 30) by Forsyth (2005) as a consequence of limited time and recognition that sufficient data would be obtained for a baseline survey (Forsyth 2014 pers. comm.). Further surveys with larger sample sizes would be useful to increase the precision of the data and estimates of deer abundance.

This study was based on faecal pellet surveys during winter 2014. This may lead to a seasonal bias in the results as deer population densities may fluctuate seasonally in response to changes in the availability and quality of food resources or other factors (Godvik *et al.* 2009). Habitat utilisation therefore may also depend on seasonally available forage (Thirgood 2009) and deer may descend from higher altitudes during winter or summer months in search of better shelter and forage (Downes 1983). Despite these considerations, Bennett (2008) found no correlation between season and population abundance, suggesting that seasonality is not an influence on estimates of deer abundance in Victoria. Further research on this aspect would improve our understanding of seasonal deer movements and habitat utilisation.

Site Occupancy

Population abundance estimates are useful to wildlife managers as they provide an indication of the approximate size of the target population. However they do not provide other critical information, such as habitat preferences, which is needed for targeted management. An understanding of the factors that influence site occupancy and the spatial exploitation of preferred habitats assists land managers to establish informed and targeted control programs (Gormley *et al.* 2011).

Many studies have established that vegetation type is important for deer for both food and cover (e.g. Bentley 1998; Downes 1983). On the basis of these studies, it could be assumed that EVCs would be a robust predictor of deer occupancy. However several studies in Victoria have found that EVCs in forested environments are not a good predictor of deer

occupancy, as there is little difference in abundance among EVCs (Bennett and Coulson 2011; Forsyth *et al.* 2009).

The faecal pellet index (FPI) method developed by Forsyth (2005) was found to be a reliable indicator of site occupancy categorised by EVC in the fringe country of the Nariel Valley. The FPI method showed that wild deer are present within all four EVCs in the Nariel Valley (Figure 3.2). No significant differences were found in deer abundance between Herb-rich Foothill Forest, Heathy Dry Forest and Grassy Dry Forest. However deer abundance in Shrubby Dry Forest was significantly lower than Herb-Rich Foothill Forest and Heathy Dry Forest (Figures 3.2; 3.3; 3.4). Herb-Rich Foothill Forest and Heathy Dry Forest had the highest likelihood of deer occupancy.

High variation was found in this study in faecal pellet counts within each of the EVCs surveyed. These results support the findings of Bennett and Coulson (2011) and Forsyth *et al.* (2009) that indicated that vegetation type is not the main influence on deer occupancy as indicated by faecal pellet counts. Instead other factors such as altitude, access to water, aspect cover and proximity to cleared land may be more important determinants for preferred deer habitat.

In the YRNP, Forsyth *et al.* (2009) found that the abundance of faecal pellets reduced with increasing distance from water and with increasing elevation. They suggest that elevation is not likely to have been a major limiting factor, as sambar deer occur at elevations from sea level to >2000 m, in their native range; which is considerably higher than the maximum elevation (940 m) sampled in the YRNP (Forsyth *et al.* 2009; Whitehead 1993). However, elevation was found to be strongly positively correlated with distance from water, so it is more likely that the quality and quantity of food favoured by deer declines with increasing elevation (Forsyth *et al.* 2009).

In the Nariel Valley, deer were least abundant in Shrubby Dry Forest, which typically occurred on exposed aspects such as ridge-lines and medium to steep upper slopes. In some areas there was a well-developed medium to low shrub layer; however the dominant characteristic of this EVC was a very sparse ground layer. The quantity and quality of forage observed in Shrubby Dry Forest during this study was comparatively lower than the other EVCs. Therefore the hypothesis that deer faecal pellet abundance varies with quality and quantity of food (Forsyth *et al.* 2009) may explain why lower faecal pellet counts were recorded in this EVC.

Other factors such as aspect, which is important for thermal protection and/ or protection from exposure to wind (Bentley 1998), and distance from improved pasture (Mason 2001) have been found to be other important factors in the preferred habitat of deer. While these factors remain important consideration in explaining site occupancy of deer in the Nariel Valley, further research is required to explore such drivers of habitat preference.

Hunting pressure

Shrubby Dry Forest and Grassy Dry Forest are typically more open than the other EVCs assessed. Anecdotal evidence suggests that during cooler weather conditions deer tend to like bedding in vegetation with sparse tree canopy and mid-story layers on north and east facing slopes in order to maximise the benefit of warmth from the sun (Mason 2001). However these vegetation types are also more accessible for hunters as deer are easier to sight, stalk and shoot. Therefore these EVCs may experience a higher level of hunting pressure, particularly during cooler weather. Despite the behavioural preference of deer to maximise the thermal benefits offered by these EVCs, it is possible that they have responded to increased hunting pressure in these areas by avoiding more open areas where they feel vulnerable, and this may be reflected in the site occupancy indicated by FPIs of deer. Further research to test this assumption would be beneficial for informing management strategies, in particular to enable a greater understanding of how deer populations respond to hunting in the context of EVCs.

The results from this study provide a spatial snapshot of site occupancy during the winter months but do not provide temporal information on deer activity and habitat use. It cannot be deduced from this method the time of year at which deer use specific habitats such as gullies, ridges or the face of hills. Anecdotal evidence from hunters suggests that deer move into gullies during the warmer summer months and seek refuge from cold conditions on spurs and ridges with a sunny aspect during winter (Mason 2001). Further information regarding deer behaviour, daily movements and home ranges in forested environments in north east Victoria would be needed to draw robust conclusions regarding factors that may influence habitat utilisation.

Deer Damage

Deer are large herbivorous ungulates, with breeding and territorial behaviours that have been found in Australia and in international studies to have a detrimental impact on natural environments. Deer damage has been found to include: a reduction of plant biodiversity and biomass through overgrazing and selective browsing, physical damage to vegetation from trampling, thrashing and antler rubbing, fouling of water holes, dispersal and spread of weeds through faecal matter and hair, increased disturbance of soil and native vegetation along frequently used game trails, and competition with native species for food and shelter (Bennett and Coulson 2011; Bilney 2013; Côté *et al.* 2004; Jesser 2005; Keith and Pellow 2005; Peel *et al.* 2005). Sambar deer have been recognised as a potential threat to biodiversity of native vegetation in Victoria and have been listed as a 'potentially threatening process' under the *Flora and Fauna Guarantee Act 1988*.

This study found evidence of many of these negative impacts, particularly to vegetation and soils in all four EVCs. This indicates that damage from deer represents a serious conservation concern. The three deer species in the valley have behavioural differences and may have differing environmental impacts (Parks Victoria 2005). This study did not attempt to differentiate damage caused by the various species of deer. For the purpose of this research, damage was categorised into five groups: antler rubbing, trails and hoof prints, wallowing, thrashing and trampling, and browsing.

The level of damage in the four EVCs followed the same general trends that were displayed in the abundance data, indicating that Herb-Rich Foothill Forest and Heathy Dry Forest experience the most damage due to deer. However diverging from this trend, Shrubby Dry Forest which had the lowest abundance of deer, experienced a higher frequency of damage compared with Grassy Dry Forest (Figure 3.5). This apparent anomaly might be because damage is more difficult to detect in grassland environments, or that animals use the habitat in different ways, e.g. stags for instance might prefer Shrubby Dry Forest for signposting or competition activity during rut. Herb-Rich Foothill Forest and Heathy Dry Forest tended to be located on lower hill slopes where conditions were moister, therefore impacts to soils were more easily observed.

The types of damage observed in this study were consistent with other studies undertaken in south-east Australia (Bennett 2008; Bennett and Coulson 2011; Bilney 2013; Keith and Pellow 2005; Peel *et al.* 2005). The following sections outline the main types of environmental damage due to deer observed in the Nariel Valley and the implications.

Antler rubbing

A small proportion (3 %) of the total damage observed within all plots surveyed was rubbed trees (Figure 3.6). However, many rubbed trees were observed outside of plots during the field work (Figure 3.8), therefore the data did not accurately reflect what was observed during the extensive reconnaissance of the forest fringe. Antler rubbing occurs as part of the annual cycle of antler development growth and shedding. Male deer develop antlers from around the age of two years. Stags go through an annual cycle in which antlers are grown as soft highly blood-rich structures (in velvet) which harden to form the mature bone-like structures which are the antler. These are used for fighting between stags and are shed at the end of the mating season. Stags rub their antlers on trees during the transition phase from soft to hard antlers in order to remove the velvet from the surface of the antler and to harden and sharpen the structure. Dominant adult stags also rub their antlers on trees to signpost their territory (Bentley 1998).

Antler rubbing typically results in cuts or abrasions on the bark of a tree. This type of damage may be sufficient to retard a tree's growth or in extreme cases ringbark the tree which will cause it to die (Bennett 2008; Bennett and Coulson 2011; Bilney 2013; Peel *et al.* 2005). Antler rubbing can also make plants more susceptible to wood-boring insects and fungal infections and so reduce fitness of individual plants (Bennett and Coulson 2011).

Several studies suggest that deer preferentially select particular tree species to rub depending on characteristics such as plant morphology, stem diameter and aromatic properties (Bennett 2008; Bennett and Coulson 2008; Bilney 2013; Ramos *et al.* 2006). In Victoria, some species of trees are particularly vulnerable to antler rubbing e.g. Yellowwood (*Acronychia oblongifolia*) (Bilney 2013), Shiny nematolepis (*Nematolepis wilsonii*) (Bennett and Coulson 2011), and Cherry ballart (*Exocarpos cupressiformis*) (Peel *et al*. 2005), although the reasons for this preference are unclear.

Rubbing can also result in increased levels of tree mortality and reduced regeneration of over-story species (Bilney 2013). A few Cherry ballart trees were found to have died as a result of antler rubbing in this study. Cherry ballart trees observed during this study had all experienced considerable rubbing, suggesting that this is a preferred species for rubbing, and as such is particularly vulnerable.

The comparatively short timeframe of this study made it difficult to quantify effects of antler rubbing on trees. Nevertheless, the extent and severity of antler rubbing of trees observed in the Nariel Valley suggests it has the potential to become a major conservation problem which will intensify with an increased deer population.

Trails and hoof prints

Deer trails are produced from the repeated movement of deer along preferential paths through the landscape. Evidence of deer activity was ubiquitous on every transect surveyed, either in the form of hoof prints or trails. Clearly defined trails were observed on many of the hill slopes (Figure 3.9) with surface deformation and compaction more evident on soils in moister areas e.g. gullies compared with drier areas e.g. rocky ridge-tops. Trails ran parallel with the forest and farm boundaries, came down the face of hills, or followed drainage lines. Trails were not confined to open country as they often broke through thick vegetation. Physical damage due to deer trails, as other researchers have noted (Peel *et al.* 2005), tend to be reasonably constrained and do not cover a large spatial area. However deer trails bisect the understory and create movement corridors along which introduced predators such as cats, foxes and wild dogs can move to access areas that otherwise would be largely inaccessible (Peel *et al.* 2005). This increased creation of trails through the bush causes fragmentation and increases predation pressures on small native mammals that rely on dense vegetation for cover (Claridge 1998; May and Norton 1996).

The number of clearly defined and well-worn trails is interpreted as supporting the inference that the local deer population is high to very high. However it is unclear as to whether the trails are from a restricted localised population or whether the trails form part of a larger network which is used by mobile deer populations moving throughout the broader region. It is also unknown whether these trails are only used seasonally or consistently throughout the year. There is abundant evidence of an active deer population which can be observed from the hoof prints and trail formation. However more research would help to substantiate the relationship between trails and abundance of hoof prints with deer abundance.

Wallowing

Wallows were observed throughout the Nariel Valley in areas of high soil moisture, including drainage lines and seepage areas (Figure 3.10). Wallowing is an integral part of sambar, fallow and red deer social and sexual behaviour (Bentley 1998; Mason 2001; Massei and Bowyer 1999). Studies have shown that deer access to waterways can cause water quality to decline (McDowell 2007). Wallowing by deer has the potential to impact on the catchment area by interfering with springs, soaks and drainage lines, increasing concentrations and loads of contaminants such as nitrogen, phosphorus, faecal indicator bacteria (*Escherichia coli*) and sediment (McDowell 2007). Wallows also result in increased erosion, as they are often located along drainage lines and in low-lying areas such as creek beds, both of which are especially susceptible to erosion during high rainfall (Peel *et al.* 2005).

The Nariel Valley catchment provides an important role in supplying critical human water needs for the town of Corryong. Any decrease in water quality in the catchment is likely to impact on the town's water supply. Furthermore, a reduction in water quality in the catchments of the tributaries of the Murray River will impact downstream users and river health more broadly. Any increase in deer numbers is likely to negatively affect water quality and increase the likelihood of water contamination.

Thrashing and trampling

Damage caused by thrashing and trampling was observed in a small proportion (2 %) of the survey plots (Figure 3.6); however, as for antler rubbing, this did not accurately reflect what was observed during the field study. Observations during the extensive reconnaissance of the valley revealed extensive localised damage by thrashing and trampling (Figure 3.12). Understory vegetation was significantly reduced along game trails and in encampment areas. It is unclear exactly what specific activities caused the various types of damage that was observed. However it is thought that behaviours such as fighting, marking territory, and encampments are the likely causes of vegetation destruction from thrashing and trampling.

Observed structural damage included creation of opened up areas, and the death or reduced fitness of individual plants. Sheltered gullies were found to be particularly vulnerable to the effects of deer trampling with denuded and opened up areas frequently observed. In the Nariel Valley, vegetation in gullies is usually relatively dense, with climbers, broad leaf shrubs, tree ferns and a variety of ferns, shrubs and mosses (Parks Victoria 2014). A study by

Peel *et al.* (2005) found that rainforest communities within gullies are particularly vulnerable to deer activity as they provide preferred habitat for sambar deer. The main threats identified by Peel *et al.* (2005) included alteration of successional dynamics at all levels, which inhibits regeneration thereby leaving soils exposed. This can lead to a change in moisture levels in gullies and failed gap regeneration leaving gullies denuded.

While the results of this study only detected minimal damage by thrashing and trampling (2% of survey plots), observations indicated that deer were causing significant damage through this behaviour. Thrashing and trampling represent a serious threatening process and are a conservation concern particularly for plant communities within gullies.

Browsing

Wild deer (especially sambar) are known to be dietary generalists and opportunistic feeders incorporating a wide range of plant species into their diet (Bentley 1998). Evidence of browsing was frequently observed, occurring in 27 % of the plots surveyed. Browsing of young and old foliage, shoots and branchlets was observed on a range of plant species, with complete defoliation of some individual plants occurring (Figure 3.13).

Deer typically browse on the lowest 2 m tier of forests, therefore it is difficult to partition deer browsing from the effects of other herbivores, particularly in the lower portion (Husheer *et al.* 2003). Consequently, there is a risk that browsing in this study was incorrectly attributed to deer. This error is unlikely to be significant however because there were limited scats of other herbivores e.g. wallaby, kangaroo etc. in the area study area, whereas deer faeces were observed frequently. Regardless, the cumulative effect of browsing by deer and native species is an important conservation concern because it could prevent the growth of plant canopies above browse height (Keith and Pellow 2005).

The extent and range of plant species affected by browsing in the Nariel Valley is consistent with other studies conducted in the Royal National Park (RNP) and the Yarra Ranges National Park (YRNP). These studies found deer to be adaptable dietary generalists (Bennett and Coulson 2011; Keith and Pellow 2005). Deer browsing appears to be spatially variable, with some plant species heavily browsed in some areas and relatively unaffected in other areas (Keith and Pellow 2005). Browsing of plant species can cause death or the reduction of fitness for individual plants (Peel *et al.* 2005). In addition reproductive output of plants can be affected by the browsing of flowers, seeds, fruits and seedlings (Peel *et al.* 2005).

Sustained and preferential browsing by deer may alter the structure and composition of forest communities, including ground cover, understory, sub-canopy and forest canopies. These changes occur if browsing reduces the regeneration of favoured plant species and alters the relative competitive ability of plants within a community (Dolman and Wäber 2008; Gill and Fuller 2007; Hall and Gill 2005; Husheer et al. 2003; Rooney and Waller 2003). With selective browsing from deer, forest communities may experience an increase in the relative abundance of browse-tolerant species and a reduction in browse-intolerant species (Rooney and Waller 2003). However the extent to which this is occurring remains unclear for some environments as it not known whether a reduction in seedling densities from deer herbivory will lead to a reduction in adult plant abundance, or if the browsing is just replacing mortality that would have occurred during self-thinning phases (Husheer *et al.* 2003).

The loss of understory cover from browsing pressure may impact on other native animal species by causing a loss of suitable habitat for them. Destruction of the understory cover of shrubs and saplings reduces the vertical structural complexity of forests (Rooney and Waller 2003). This can especially compromise the habitat of small birds that require a dense shrub layer for cover and nesting (deCalesta 1994).

Whilst a longitudinal study would be required to understand the long-term effects that deer browsing is having on the vegetation community and structure, the preliminary results from this study indicate browsing is one of the major ways in which deer impact the environment. Based on the data in this study and the considerable evidence amassed from other studies, it is likely that browsing by deer, cumulatively with other animals, is having a detrimental impact on the vegetation communities of the Nariel Valley. If no action is taken, this may lead to irreversible changes in the ecology of the area.

Limitations

The design of the survey imposed some limitations on the interpretation of the field work results. Because of the short time frame for the project and the presence of sympatric herbivore species in the research area, there are difficulties in differentiating between browsing impacts caused by deer and that from other herbivores. Herbivory impacts by deer may be additive though still profound (Dolman and Wäber 2008; Putman and Moore 1998). It is also possible that some signs of damage to local vegetation and environments could have been overlooked or erroneously attributed to deer. However it is unlikely that most of the

damage observed to the local vegetation was caused by native species because there were few signs of wallaby or other native herbivore scats in the area, whereas deer faecal pellets were abundant.

The research undertaken was appropriate for a pilot study. However it may be possible to reduce the level of error associated with sympatric species in future studies by erecting exclusion plots, which are designed to distinguish the effects of deer and native herbivores.
It is also noted that individual plant species were not recorded and in the absence of such data no inferences can be made regarding the vulnerability or susceptibility of particular plant species to browsing by deer.

Conclusion

In summary, this research reveals that there is relative high abundance of deer in the fringe country of the Nariel Valley. However as this is the first study investigating deer abundance in the Nariel Valley, no conclusions could be drawn as to whether the population is either in decline, stable or increasing. It is unknown what the plausible upper bounds of this deer population are, and what is the potential carrying capacity of the valley and the surrounding country. Long-term monitoring of deer populations will be necessary in order to develop a greater understanding regrading population dynamics and trajectories.

Habitat preference appears to be influenced by a range of factors, therefore stratification of the study area by EVC may not be the best way to identify preferred habitat. However the forested habitat in close proximity to cleared land/improved pasture appears to be the most highly favoured habitat. Shrubby Dry Forest was the least favoured of the habitats in the Nariel Valley, however there was no clear distinction between any of the other EVCs.

The level of damage observed in the Nariel Valley suggests that environmental damage could be a conservation concern if the population continues to increase. A reduction of deer populations would likely slow or reverse some of the effects associated with deer herbivory. It is unknown what level of reduction is required to reduce damage to an acceptable level (Keith and Pellow 2005). Before land managers can justify increased control of deer, there must be more comprehensive evidence of structural changes to plant communities that are occurring in the study area. What remains unknown is the extent to which the ecosystem can adapt to deer impacts and at what point the impact of deer will be so profound that the ecosystem will reach a tipping point.

The need for further research cannot be over-stated; deer are evidently causing damage to the natural environment so longitudinal studies will be required to enhance our limited knowledge regarding the many factors identified in this study.

CHAPTER 4 - SOCIAL RESEARCH

METHODS

Research design

As presented in Chapter 1, the main sociological aims of this thesis are to:

a) Assess the attitudes of local landholders in the Nariel Valley toward wild deer, including their benefits and damage.

b) Determine the relationship, if any, between local landholder attitudes and perceived deer damage in the Nariel Valley.

c) Identify the options for managing deer in the valley and the likely attitudes of the local stakeholders to their application.

To address these aims, a concurrent mixed methods research (MMR) design was selected. This involved the use of both quantitative and qualitative methods, with findings coming from two sources: a questionnaire survey (quantitative) and interviews (qualitative).

As Greene (2008, p.20) explains:

> "A mixed methods way of thinking is an orientation toward social enquiry that actively invites us to participate in dialogue about multiple ways of seeing and hearing, multiple ways of making sense of the social world, and multiple standpoints on what is important and to be valued and cherished. A mixed methods way of thinking rests on the assumptions that there are multiple legitimate approaches to social enquiry and that any given approach to social enquiry is inevitably partial. Better understanding of the multifaceted and complex character of social phenomena can be obtained from the use of multiple approaches and ways of knowing. A mixed methods way of thinking also generates questions, alongside possible answers; it generates results that are both smooth and jagged, full of relative certainties alongside possibilities and even surprises, offering some stories not yet told…"

A MMR design is therefore useful when investigating the perspective of landholders that are likely to have different attitudes, as is likely given the diversity of land uses in the Nariel Valley.

The MMR design also helps to gain insight into different levels of the analysis and to eliminate or reduce potential gaps in the data (Creswell 2009). This approach is known as 'complementarity', whereby two methods in a MMR design contribute a different means of gaining information about a subject; thus complementing the knowledge generated by the other method. The multiple methods thereby enrich the analysis and understanding of the multi-faceted, complex nature of the social world (Gilbert 2008). In addition, MMR is useful because a purely quantitative research design can fail to adequately inform about the human motivation behind certain preferences and behaviours (Creswell 2009). Understanding of attitudes and behaviours is essential to a study such as this one, which aims to inform about the most feasible and effective approach to wild deer management given the disparate stakeholders in the study area and the likelihood of differing perspectives on deer impacts and management.

The MMR was conducted concurrently, allowing efficient collection of both forms of data at the same time. The data were then integrated during the analysis and interpretation phases of the study.

Philosophical approach

The philosophical issues surrounding MMR have been the focus of much discussion (Tashakkori and Teddlie 2010). There are many different stances regarding the appropriate paradigm for MMR. Paradigms reflect worldviews and all-encompassing perspectives on the world (Tashakkori and Teddlie 2010, p.55). Examples of such stances include:

- Paradigms are different and therefore should not be mixed
- Paradigms are independent and can be mixed and matched
- Paradigms are different and should be kept separate in MMR.

However it is important to acknowledge that multiple paradigms may be appropriate to any particular research study and may inform about different aspects of the research. This research study therefore took a pragmatic approach, which is often used in MMR (Moon 2011). A pragmatic approach is where 'little attention is paid to paradigm differences in actual research practice, and different methods are not treated as exclusive to a particular perspective' (Gilbert 2008, p.139). Pragmatists are not committed to any one philosophy, which enables the researcher to draw from multiple worldviews. An advantage of this

approach is that, 'pragmatism opens the door to multiple methods, different worldviews, and different assumptions, as well as different forms of data collection and analysis' (Creswell 2009, p.11).

The pragmatic paradigm places more importance on the research question, rather than a particular methodology (Tashakkori and Teddlie 1998). The choice of methods, whether qualitative, quantitative or mixed, is seen as secondary to the research question. The researcher uses what they believe to be the most appropriate methodological tools to understand the problem and answer the research questions (Cherryholmes 1992).

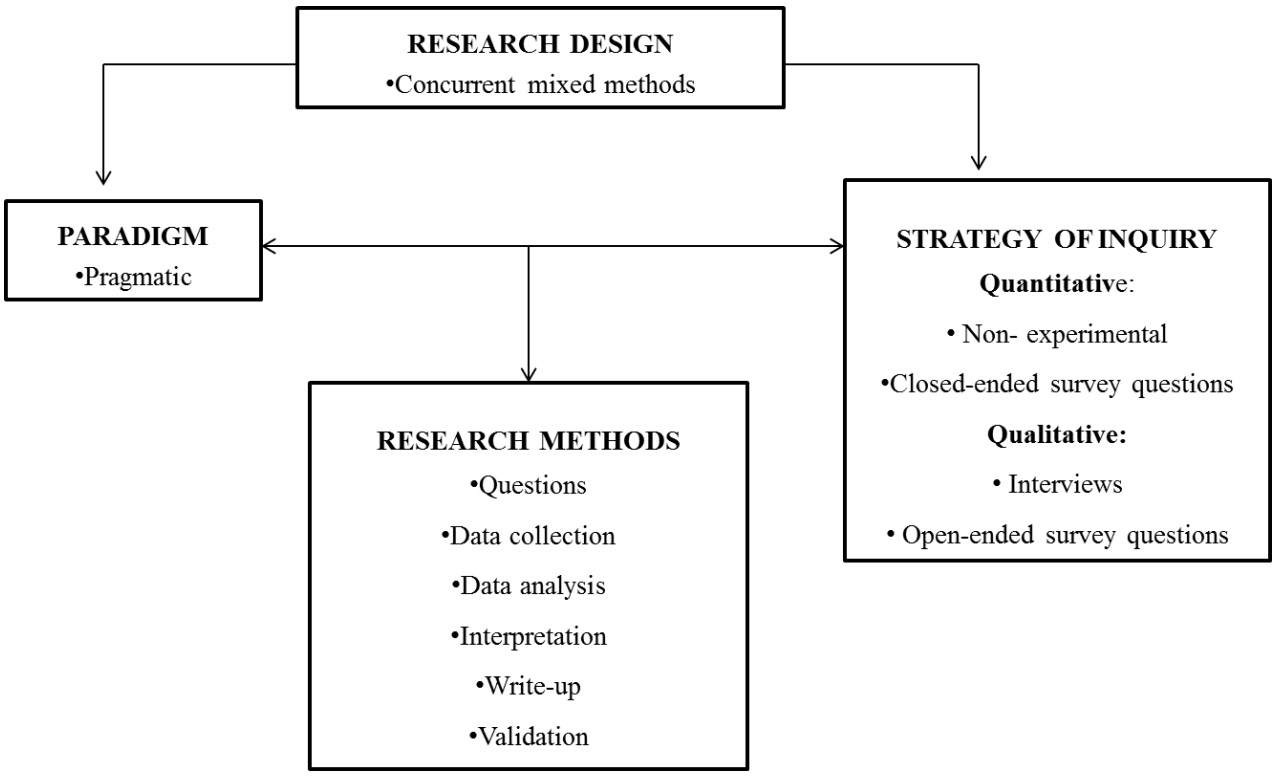

Figure 4.1 The research design framework: the relationship between the paradigm, strategy of inquiry and research methods (adapted from Creswell 2009, p.5; Moon 2011, p. 49)

Participant selection

The target population for this study included rural landholders who potentially encounter wild deer on their land, are impacted in some way by wild deer during day-to-day activities (positive or negative), and those who manage wild deer either actively or passively.

The selection of individuals for a survey is a complex process in which a balance has to be sought between cost and representativeness (Babbie 1992). As the number of landholdings in the Nariel Valley is relatively small (53), and as it is often difficult to get a high proportional return rate from attitudinal surveys (White *et al.* 2005), an attempt was made to survey one respondent per household from the entire population of the study area. This census method is attractive for small populations because it eliminates sampling error and may provide data on all individuals in the population (Israel 2009).

Data collection

Surveys were carried out in person because access to personal details about local landholders, such as postal addresses, was difficult to acquire. This was mostly in part due to the regional electoral rolls no longer being publicly available for distribution purposes (AEC 2011) and that lists of addresses such as the Australia Post residential database are tightly controlled and expensive due to their commercial value (FDS 2011). The Nariel Valley also has a relatively high proportion of lifestyle properties which are inhabited infrequently or have no dwellings or postal address. Furthermore, face-to-face interviews allow the interviewer to build rapport with participants which 'keeps the respondent motivated and interested in answering the questions truthfully' (Oppenheim 1992, p.89).

Whilst every attempt was made during this research study to carry out a complete census, the mixture of absentee and full-time residents made this difficult. The nature of a mixed rural economy meant that people often worked away from the area or were not available for interviews during the survey period.

Landholdings occupied by the very elderly (85+) were excluded from this study. It was deemed inappropriate to survey or interview people in supported care, given the possibly fragile nature of their health. It is believed that the exclusion of these individuals (n = 3) did not affect the findings of this study.

Landholders for whom contact details were publicly available (e.g. via the phone directory) were contacted to ask if they would be willing to participate in the study and to organise a time that would best suit them to complete the survey and/or interview. A direct home visit was used where people could not be contacted by phone, or where people were unable to suggest a suitable time (often due to the unpredictable nature of farming activities). Many surveys were conducted on weekends and during the evening, or opportunistically during the week whilst landowners were between jobs such as milking, tending stock or coming home from work.

Because it was difficult to acquire contact details through conventional means such as phone directories, the data collection methodology evolved into an 'opportunistic' 'snowball sampling' approach, where participants were asked for contact details of neighbours and friends living in the valley. This approach worked well as the population is small, and most people in the community know one another.

Respondents had the option of participating in an interview, a survey or both. Concurrent surveys and interviews increased the efficiency of the research and promoted a better response rate. Surveys took on average 20 minutes to complete, and interviews took on average one hour. It was also less imposing on the interviewees to conduct a survey and interview concurrently, which is an important consideration because many of the local landholders run the family farm and their time is constrained.

As interviews and surveys were often conducted during the evenings and in people's homes, I was accompanied by a field assistant to ensure personal safety.

Questionnaire survey – quantitative

Surveys were conducted during May through August, 2014. The survey was designed to collect information on five categories: general demography; human-deer interactions; management of deer, including attitudes to deer control methods; opinions regarding the declaration of deer as a pest; and attitudes towards deer and other wildlife species. Survey questions were selected and adapted in consultation with practicing social scientists. Many of the same questions that Finch and Baxter (2007) used in their survey of landholder attitudes to deer management in Queensland were used to allow for comparison between rural

landholders from north-east Victoria and Queensland; two regions with differing legislation and management.

The resulting questionnaire consisted of 25 questions including closed format questions with categorical response options, semi-structured questions, open-ended questions and likert scale questions (see Appendix 5 for full survey instrument). The survey was limited to 25 questions to maximise efficacy and likelihood of participation. One instrument used in the survey (see Appendix 5, Q.14) which required respondents to rank pest species in order of importance from 1 – 10 proved to be ineffective because people did not necessarily have a stepped hierarchy of pest animals. People were unable to fill in the question in the way that it was intended because there was confusion or ambiguity in relation to the question. Therefore the results from this question were not used in this study.

The questionnaire was reviewed prior to use in the research study by an expert in stakeholder engagement and management of invasive species. It was also pre-tested on a number of subjects from outside the survey population to ensure that the questions were unambiguous and easy to comprehend. Some modifications were made to the wording of questions as a result of this prior test.

Interviews – qualitative

Semi-structured face-to-face interviews were conducted with 29 landholders to qualitatively supplement the questionnaire data. One-to-one interviews were selected as the best method to elicit landholders' perceptions and attitudes toward wild deer management. This is because face-to-face interviews enable researchers to gather detailed attitudinal and experiential information from respondents, in an environment where their individual participation cannot be influenced by so called 'group effects'. Group effects can be encountered in other techniques, such as focus group discussions, and can skew survey findings (Powell and Single 1996).

Open-ended questions were used during the interview to understand how respondents felt about deer in the Nariel Valley or on their property; whether they had a positive or negative perception of the deer; what some of their main concerns were in regard to deer populations; what management strategies would be acceptable to them to control deer populations; and whether they believed deer should be declared a pest in the state of Victoria.

The advantage of open-ended questions is that respondents are not influenced by alternatives provided in a prepared set of replies; e.g. closed-ended questions (Oppenheim 1992, p.81) and are free to express their views in their own words. Open-ended questions can therefore provide more meaningful information and also allow for unexpected responses, which the researcher was unaware of and which may lead to new areas to be explored (Bryman 2012; Oppenheim 1992).

Answers to open-ended questions were written down during the interview. After each interview, my field assistant and I would discuss the interview to triangulate the data. This process is known as 'investigator triangulation', and is a method that uses multiple rather than single observers. This process enables clarification and identification of emergent themes and in this study helped to make sure that my perception and understanding of the interview was an accurate reflection of the participants' responses.

Data Analysis - Quantitative

Questionnaire data were analysed using IBM SPSS Statistics Version 21. The quantitative analysis of the sociological data consisted primarily of univariate descriptive analysis. This approach is commonly used in the analysis of quantitative data to summarise the characteristics of a phenomenon (Blaikie 2003). Frequency tables were used for much of the data presentation due to the relatively small sample size. Relationships between variables were identified using a bivariate analysis: chi-squared ($\chi 2$) tests.

Data Analysis - Qualitative

Interviewees were assigned an ID code relating to relevant stakeholder grouping. This was done for clarity and for analytical comparisons of responses between stakeholder groups.
The coding used was as follows: R#L (Respondent, number, Lifestyle), R#P (Respondent, number, Producer). The data were entered into and analysed using Excel and SPSS.

The discourse analysis method of grounded theory was used to analyse the qualitative data. This involved the use of memos and codes (Glaser and Strauss 1965). Memos are written records of analysis (Corbin and Strauss 2008) and are commonly used to extract major concepts from qualitative responses. Codes were developed and used to detect the major

themes amongst the responses to each question. The first stage of coding involved the data being broken down into many emergent sub-themes. Initial themes were identified using an approach based on the principles of grounded theory. This approach is where emergent rather than hypothesised themes are identified (Bryman 2012; Corbin and Strauss 2008). Sub-themes were then gradually pooled into broader categories and categorised according to the main themes that emerged. This process of synthesising helps to reduce the amount of material to a manageable level and also begins the process of cleaning, analysing and interpreting the data for later representation.

Within the thesis results section, quotes are presented from different landholders to illustrate the various dimensions of each major theme (Moon 2011). Descriptive accounts were then prepared in a word document to identify and describe the key dimensions, range and diversity of the responses.

Ethical Considerations

Prior to the commencement of each interview, it was made clear to all participants that note-taking or recording would be employed during the interview. Participants received assurance that all information gathered from the interviews and the resulting data would be subject to the rigorous safeguards and formal assurances of confidentiality and anonymity employed by the University of Canberra. A research ethics information document was prepared for each participant, guaranteeing present and future anonymity and confidentiality of information (see Appendix 6). The information document explained that respondents would be identifiable to the researcher but at no point would the individuals be made identifiable in any results or products of the research i.e. in the thesis, journal papers etc. A copy of the document was required to be signed by the participant giving their consent to participate in the study prior to commencement. All participation was voluntary and participants were advised that they were free to withdraw consent at any time.

In addition, participants were provided with an information sheet explaining the purpose of the study, which outlined the survey aims, approach, ethical considerations and some limited information on deer in Australia (see Appendix 7).

All participants were asked at the end of the survey/interview if they would like to receive a copy of the research results once they were collated. Of the 34 individuals surveyed, 19 requested a summary of the research.

The survey methodology and information documents had been assessed and approved as appropriate by the Human Ethics Committee of the University of Canberra before commencement of the sociological research (see Appendix 8).

RESULTS

Quantitative Results - Questionnaire

Table 4.1 General respondent characteristics.

Lifestyle properties		Production properties	
Land Size (ha)	Occupancy (yrs)	Land size (ha) (use)	Occupancy (yrs)
< 1	0 - 1	154 (Dairy)	1 - 5
< 1	0 - 1	8 (Beef)	5 - 10
16.5	0 - 1	880 (Beef)	15 +
32	1 - 5	607 (Beef)	15 +
1.2	1 - 5	129.5 (Beef)	15 +
4	5 - 10	667 (Beef)	15 +
3.2	5 - 10	405 (Dairy)	15 +
8.1	5 - 10	365 (Beef)	15 +
5	10 - 15	404 (Dairy)	15 +
4.8	10 - 15	126 (Beef)	15 +
2.2	10 - 15	100 (Beef)	15 +
2	10 - 15	485 (Beef)	15 +
1.2	15 +	283 (Beef)	15 +
40	15 +	101 (Beef)	15 +
1.2	15 +	250 (Beef)	15 +
1	15 +		
81	15 +		
38	15 +		
1.5	15 +		

Of the 52 properties in the Nariel Valley, 34 landholders were surveyed; this equates to a response rate of 63 %. All of those surveyed owned their property. There was a higher proportion of lifestyle property owners (56%) included than primary producers (44 %). Beef and dairy were the production enterprises (Table 4.1).

The size of landholdings ranged from < 1 to 880 ha. The average landholding was 13.5 ha for lifestyle residents and 331 ha for primary producers (Table 4.1). The wide range of property sizes reflects the diversity of land use.

Of the respondents surveyed, 58 % have lived in the Nariel Valley for more than 15 years, 24 % have lived in the valley for 5 - 15 years, and 18 % have lived in the Valley for less than 5 years (Table 4.1). Most primary producers have lived in the valley for a long time (i.e. at least 15 years) as have some lifestyle property owners. However, most people who have moved into the valley more recently as residents are lifestyle property owners. Most of these are on relatively small blocks (i.e. less than 5 ha) but some lifestyle blocks are as large as 81 ha and one primary producer's block is only 8 ha.

Experiences with Deer

In the Nariel Valley, 94 % of the surveyed landholders reported that they have deer on their property. Wild deer are *always* present according to 53% of landholders while 41% stated that deer are *sometimes* present. The remaining 6 % reported that wild deer are *never* on their property (Figure 4.2). The latter respondents were lifestyle property owners on small blocks of < 2 ha.

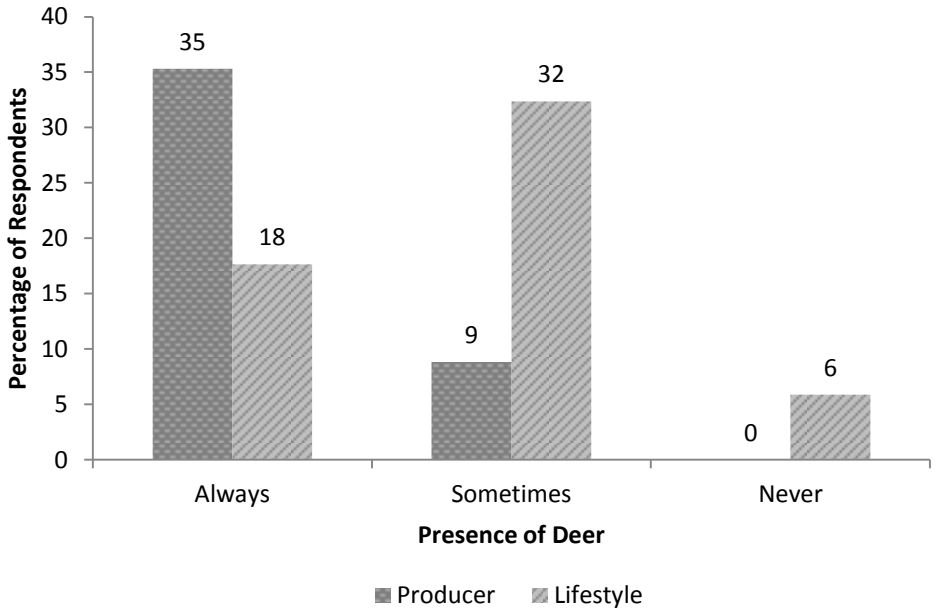

Figure 4.2 Landholder's (*n*= 34) perceptions of how often deer come onto their properties.

All landholders are aware of the presence of deer in the Valley. Almost one-third (32 %) of landholders reported that they had been aware of deer for > 10 years, 44 % had been aware of them for 5 - 10 years, and 24 % for 0 – 5 years (See Figure 4.3). Thus, most (44%) of the respondents said that they had become aware of deer in the valley in the last 5 – 10 years.

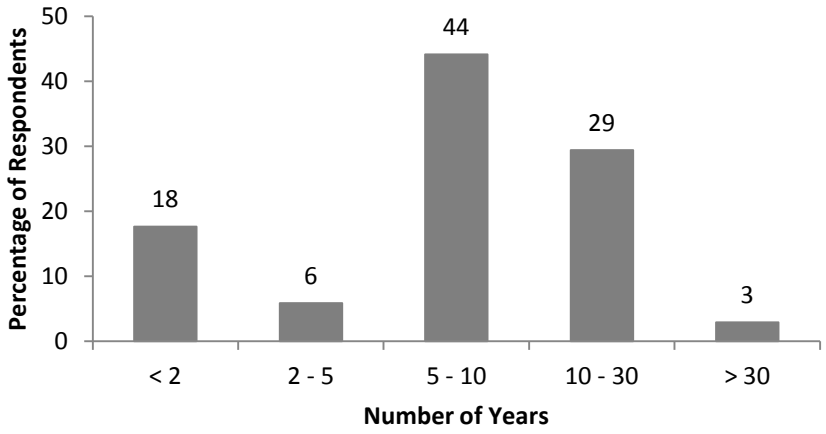

Figure 4.3 Duration that respondents had been aware of deer on their property or in the Valley.

Most respondents reported having damage on their property due to deer (59 %). There was a significant relationship between landowners being aware of damage and the type of property enterprise, χ^2 (1, n = 34) = 10.261, p = 0.001. Perceived damage was much higher amongst producers (70 %) compared to lifestyle property owners (30 %) (Figure 4.4). The main types of damage included: fence damage; competition with livestock; fouling of water holes; and damage to native and ornamental trees on the property.

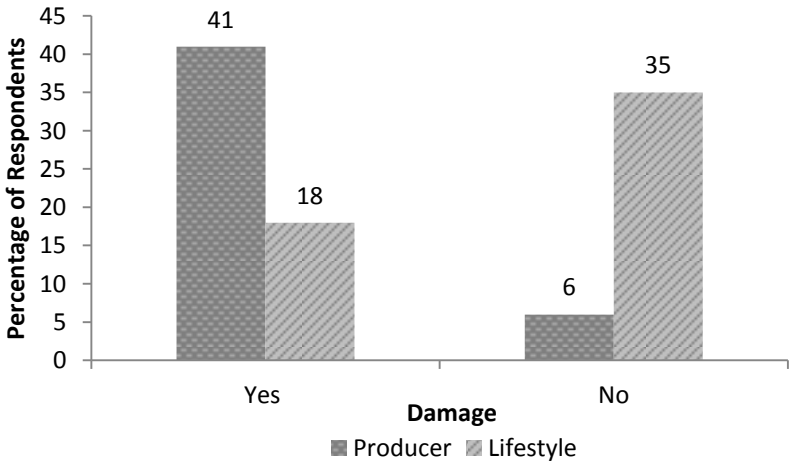

Figure 4.4 Perceived damage due to deer categorised by property enterprise.

Management of Deer

Desired deer abundance

The surveyed landholders were also questioned about the population level that they would like to see for deer in the Nariel Valley. The respondents were asked to answer by selecting one of a series of categorical response options. Most of these landholders (57 %) wanted to see a reduction in the deer population (24 % would like a slight reduction, 21 % a great reduction and 12 % eradication). A few (9 %) said that they would like to see the deer population level increase and just over one-third (35 %) said that they would like to see the population remain at its present level (Figure 4.5).

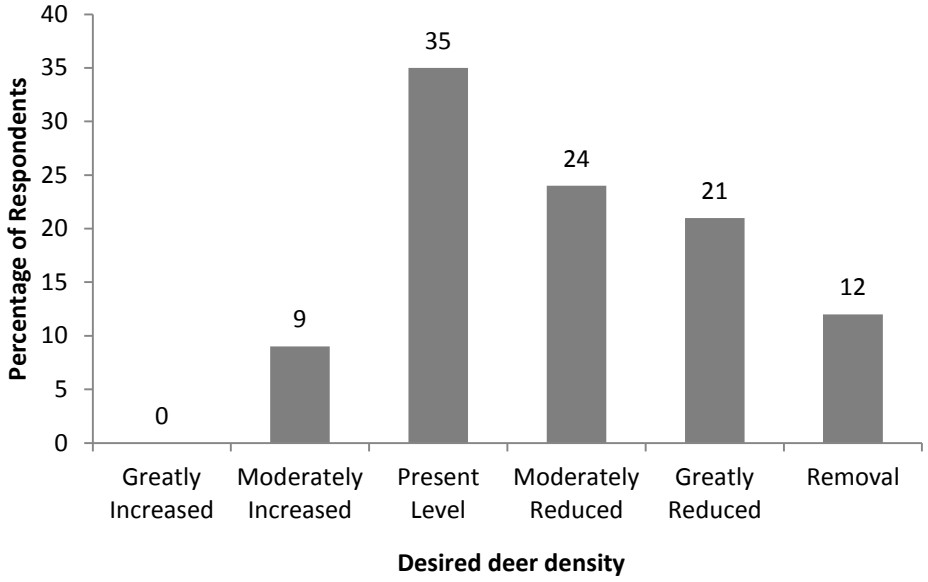

Figure 4.5 Respondents' (%) desired deer abundance levels.

There was a significant relationship between landholders who had experienced damage and the expressed desirable deer population level, χ^2 (1, n = 34) = 16.703, p = < 0.001. The majority of respondents who wanted to see the population level reduced had experienced damage that they believed was due to deer (Figure 4.6). In contrast, the majority of the respondents who had not experienced damage on their property wanted to see the local deer population either remain at the same level or increase.

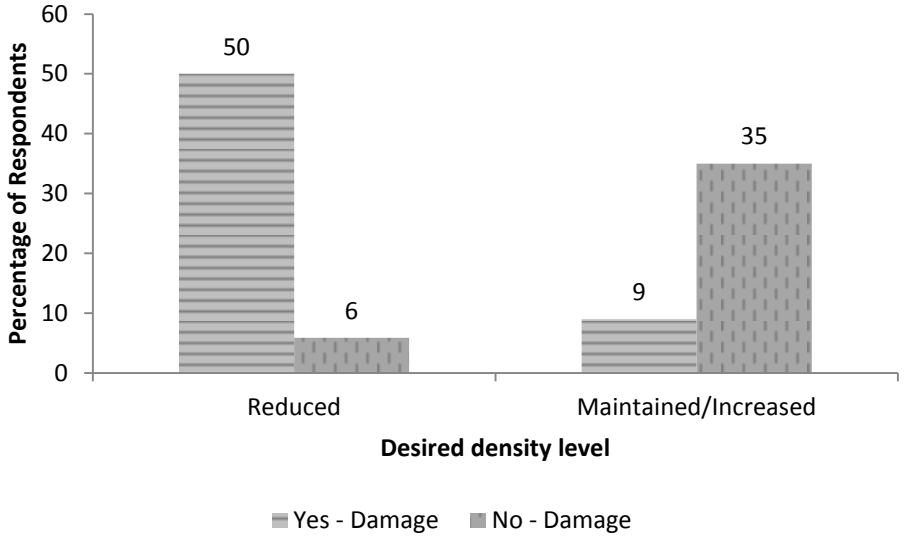

Figure 4.6 Respondents' (%) desired deer abundance levels, categorised by perceived damage.

Management techniques

Although the majority (57%) of respondents favoured a reduction in the local deer population, less than one-third of these respondents (29 %) said that they already controlled deer on their property. All of the landholders that admitted to already controlling deer on their properties were primary producers. Shooting was their primary control mechanism. Of the remaining respondents that stated that they do not control deer (71 %), most (79 %) were lifestyle property owners.

Respondents were asked in the surveys to list what management techniques they would accept if deer were to be managed. They were provided with possible responses to this question in the form of categorical response options. The favoured management methods (Figure 4.7) were game meat harvesting (37 %) and recreational hunting (31 %). Fertility

control was moderately accepted by landholders, with 19 % in favour of this method. Trapping and poisoning were least favoured, with less than 8 % of respondents supporting these methods. No management was selected as the preferred option by only 2 % of the respondents, while 3 % would like to see other forms of management, for example a government-managed cull of local deer.

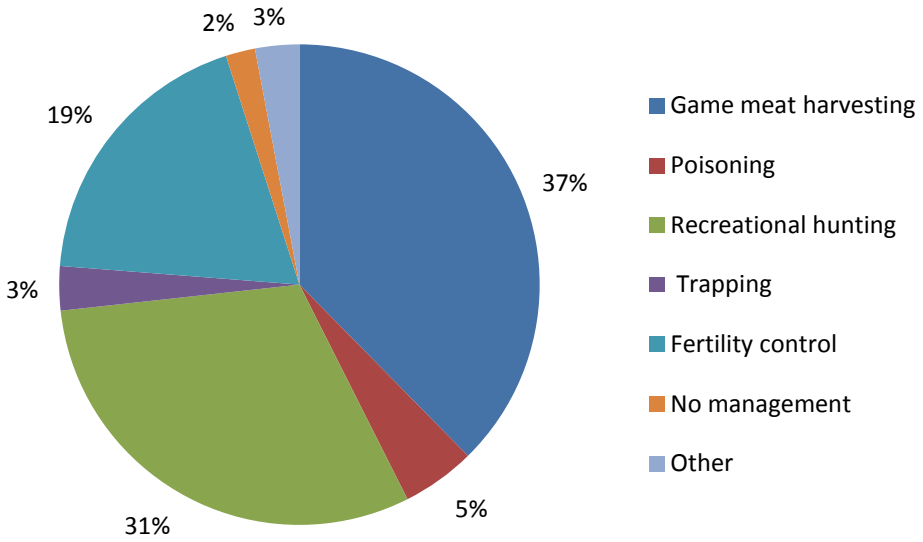

Figure 4.7 Respondents' (%) acceptance and preference to deer management strategies.

Declaration of deer as a pest

Respondents were asked if they believe that deer should be declared a pest in the state of Victoria. Most (64%) stated that they believe deer should be declared a pest (Figure 4.8). Of those that were in favour of pest declaration, 59 % were primary producers. There was a significant relationship between property enterprise and a stated preference for declaration of deer as a pest, χ^2 (1, n = 34) = 7.048, p = < 0.05. Of those landholders against pest declaration, 83 % were lifestyle property owners (Figure 4.8).

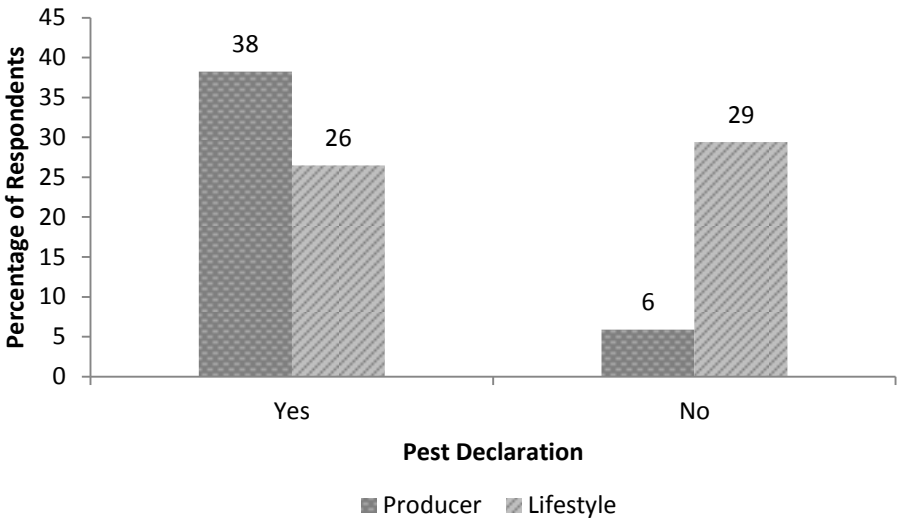

Figure 4.8 Attitudes toward a declaration of deer as a pest in Victoria by property enterprise.

Recreational Hunting

The majority of the respondents (85 %) said that they do not hunt deer for recreation, and only a few (15 %) said that they do hunt deer for recreation. There was no significant relationship between property enterprise and recreational hunting: χ^2 (1, n = 34) = 0.634, p = > 0.05). Both primary producers and lifestyle property owners participate to a similar level in recreational hunting.

Attitudes to deer

Most respondents (53%) believe that deer cause environmental damage on their property (Table 4.2). Many landholders (48 %) believe that deer are an agricultural pest on their property, and also that they are significant competitors in relation to grazing by livestock (42 %). However, just over half of the respondents were neutral or disagreed with these statements because they are not primary producers and didn't think these statements were applicable to their circumstances (Table 4.2). Many (44 %) reported that they enjoy having deer on their property (Table 4.2). Most respondents (74 %) disagreed or were neutral with the statement that deer are an asset and almost all respondents (97 %) also disagreed or were neutral about deer providing a useful source of income to their business.

Most respondents (56 %) disagreed with the statement '*I view wild deer as similar to native species';* however, a considerable proportion of respondents (39 %) agreed with the statement. The majority of respondents (65 %) view wild deer as feral pests but there was also a majority perception that deer are a game species (71 %). The majority of respondents (56 %) also believe that *'It is important to maintain wild deer populations for future generations to enjoy'* (Table 4.2).

Table 4.2 Attitudes to deer in the Nariel Valley according to the number and proportion (in brackets) of responses to posed statements

Statement	**Strongly disagree**	**Disagree**	**Neither**	**Agree**	**Strongly agree**
Wild deer cause environmental damage on my property	2 (6)	12 (35)	2 (6)	8 (24)	10 (29)
Wild deer are an agricultural pest on my property	2 (6)	9 (25)	7 (21)	8 (24)	8 (24)
Wild deer significantly compete with livestock on my property	3 (9)	3 (9)	14 (41)	8 (24)	6 (18)
Wild deer are a management problem on my property	2 (6)	14 (41)	5 (15)	9 (26)	4 (12)
I enjoy having deer on my property	9 (26)	3 (9)	7 (21)	8 (23)	7 (21)
Wild deer provide a useful source of income to my business	8 (24)	18 (53)	7 (21)	0 (0)	1 (3)
Wild deer are an asset to my property	8 (24)	12 (35)	5 (15)	4 (12)	5 (15)
I view wild deer as similar to native species	4 (12)	15 (44)	2 (6)	8 (24)	5 (15)
I view wild deer as similar to feral pests	2 (6)	9 (26)	1 (3)	16 (47)	6 (18)
I view deer as a game species	1 (3)	9 (26)	0	16 (47)	8 (24)
In general, I do not like having deer on my property	5 (15)	11 (32)	8 (24)	3 (9)	7 (21)
It is important to maintain wild deer populations for future generations to enjoy.	3 (9)	7 (21)	5 (15)	13 (38)	6 (18)

Qualitative Results - Interviews

The qualitative analysis of the interviews showed that there are three main dimensions to local attitudes towards deer: awareness, perceptions and management, with specific themes and sub-themes. The results are outlined below:

Awareness

To gauge the level of awareness that landholders have about the local deer population, respondents were asked:

- *What species of deer are you aware of?*
- *Do you think the deer population is increasing?*
- *How long have you been aware of the presence of deer in the valley?*

Three types of deer (sambar, fallow and red deer) are reported to be present within the Nariel Valley. Most landholders were aware of the diversity of deer species in the valley and many believed that '*the variety of deer in the area is increasing'* (R8L). The most commonly seen species was the sambar, followed by fallow, whereas red deer were only reported by two landholders. It is believed that red deer have only recently arrived in the valley.

According to local anecdotal evidence, deer populations appear to be increasing in the valley. Many landholders believe that deer have been present in the Nariel Valley (in low numbers) for approximately 30 years. However, there was a general consensus among the long-term residents (10 + years) that the deer population has increased significantly during the last ten years. For example, several respondents stated that:

'Deer have been in the area for 30 years but it has been in the last five to ten years that there has been a significant increase' (R32P).

Deer have always been here and deer hunters have always been coming into the Valley, but in the last five to ten years we have seen deer numbers increase, we never used to see them (deer) but now they are walking around the house!' (R33L).

'In approximately eight years I have gone from seeing none, to seeing them nearly every night, especially in winter' (R5L).

'Ten years ago I would see the odd deer in the paddock, now I would see about 20' (R10P).

There was a strongly held belief among respondents that the extensive Alpine bushfires, which impacted on the valley in 2003, contributed to a significant increase in the local deer population. One landholder theorised that *'since the 2003 bushfires, deer have been more prevalent, which could be a result of the bush being opened up'* (R29P).

Prior to this observed increase in the deer population over the last 5 – 10 years, landholders generally had little concern about wild deer: '*Twenty years ago I saw my first deer – sightings were few and far between so I didn't worry about deer much then*' (R23P). Today however, many landholders (61 %) are acutely aware of the potential issues associated with a rapidly increasing deer population. Deer populations and their management are now widely recognised as an emerging issue among the landholders that were interviewed. Even those who professed a sentimental and aesthetic regard for deer recognised that there is an immediate need for some form of control of the deer. One respondent stated: '*the deer population could get out of control if not controlled…deer breed like flies, as much as I like them they are pests' (R7P).*

Perceptions of Wild Deer

To gauge the respondents' perceptions of wild deer, people were asked about their experiences with deer (both positive and negative). The interviews revealed that there was a dichotomy of attitudes towards deer within the community. The notions of value of the deer were largely influenced by economic, social and environmental factors. The following section outlines the main effects that were found to influence the respondents' perceptions of deer.

Positive Perceptions

Economic

A small number of respondents stated that they believe that wild deer are a valuable game resource and '*an asset'* (R1L) to the community due to the economic benefits derived from recreational hunting. For example, one respondent stated that: *'deer hunting is fantastic because of the money that it brings to the community'* (R23P).

The Nariel Valley is considered by many to be a premier hunting destination and some respondents said that they believe that significant economic opportunities can be gained from

the promotion of recreational hunting. As stated by one respondent (R2L): '*hunting is good for the district because of the economic benefits that it brings… I would like to see more hunters in the area'.*

Cultural and Social

Recreation

Among those local residents who value deer, many have developed a strong cultural association with recreational deer hunting. One respondent reflected:

'It's (hunting) generational - cultural, a lot of hunters today grew up with subsistence hunting… there are three generations of hunters in my family, it's a way of life (R1L).

Some respondents reported being active members of hunting associations, such as the Australian Deer Association, which advocate the conservation of deer in the Australian landscape and increased hunting opportunities. These respondents believe that deer hunting provides important recreation for not only themselves but also for their friends and family. They thus value deer for the continuation of their cultural activity. The amount of time that they typically dedicate to recreational hunting varied from as much as 'once a week from March through to October' (R1L) to '4-5 times per year' (R31L). This shows that hunting is for some locals largely a recreational occupation and for others a seasonally available subsistence resource.

Deer as a food resource

Deer are a valued food resource for contemporary subsistence and also as a safeguard against future food limitations. One landholder recognised the importance of deer as a future resource, stating that, *'I don't mind deer being in the bush – you never know what's going to happen in the future, we might need them (as a food source)* (R34L). In contrast, another participant demonstrated their current dependence on deer, explaining that for the last six years they had not needed to buy meat: *'plenty of venison to be had, when we are running low, I just ring up my son-in-law to shoot one for me'* (R19P).

This emphasis on the food value of deer is an important factor in their control and management. Some landholders stated that they are less likely to take or kill a deer unless they can utilise the meat. One respondent explained that *'there ha[ve] been plenty of*

opportunities to take deer, but I don't if there's no need for the meat, I don't like seeing the animal wasted' (R31P).

Aesthetics

Many of the study respondents (47 %) place an aesthetic value on wild deer, and get enjoyment from seeing them in the wild. They believe that their presence enhances the appeal of the natural environment. Comments such as *'deer are cute things…pretty little things'* (R34L), *'I like deer; they are a beautiful creature'* (R2L), *and 'they are fantastic to look at'* (R23P) demonstrate this appeal and the attachment that some members of the Nariel Valley community have toward deer.

Negative Perceptions

Despite the positive perception of deer held by some local residents as discussed in the previous section, many other respondents in the Nariel Valley have negative perceptions of deer. The interviews revealed that this was mainly attributable to the residents' perceptions of damage due to deer, especially to the agricultural and natural environments. Many of the respondents that have negative perceptions of deer had suffered a financial loss directly or indirectly due to deer; e.g. loss of pasture, damage to fences, disruption of animal husbandry due to hunting activities and vehicle collisions with deer. The following section details the main reasons as to why wild deer are perceived negatively by many.

Economic

Many landholders (59 %) reported damage on their property due to deer. The nature of the damage reported by landholders was varied and extensive. It included: fence damage, erosion, fouling of water holes, degradation of dam banks, creation of trails, grazing of pasture and crops, rubbing of fruit, native and ornamental trees, and spooking and harassing of cattle. Diminution of land function - including reduced profitability of businesses and damage to the bush and cultivated environment due to deer - was a concern to many landholders.

Landholders, in particular primary producers, felt that the productivity and profitability of their land is being directly affected by deer. One respondent reported that: '*they are eating food that the cattle should be eating - 'I'm not in the business of running deer'* (R14P), while another explained that deer ate out a crop he had sown: *'once it had grown up about a foot, it was gone in two nights'* (R23P).

Deer were seen to *'damage fences regularly'* (R25P), resulting in repairs being needed to critical infrastructure. This led to costs in terms of time and money needed to fix the fences, and a consequent economic loss to landholders.

Damage to infrastructure and grazing pressure were not the only damage reported; a few landholders also reported injury to stock as a result of aggressive deer. One respondent explained that: *'Stags can be aggressive toward stock; I've had a cow injured from a stag in rut'* (R19P).

There were also concerns raised by some regarding the potential for deer to act as a vector for diseases:

'Yeah deer cause grazing pressure, fence damage but the biggest concern is that deer can carry disease which could be transmitted to stock. With an influx of deer, there could be an outbreak in disease' (R28P).

Conservation and environmental

Some study respondents (38 %) perceive deer as a threat to the natural environment, recognising that *'they (deer) are destructive in the bush and waterways'* (R16L). Several of the Nariel Valley locals believe that significant damage has occurred in the bush as a result of increased deer activity. One respondent stated that: *'In the time that I have lived here I have watched the vegetation change, which could be due to natural evolution of the bush, but [I] think that [it] is more likely due to the deer*' (R25P).

These respondents recognise that deer, an exotic ungulate, have the potential to cause significant damage to the natural environment which evolved in the absence of such animals. Some of the concerns that they raised include: *'Deer damage the bush, they are a hoofed animal so they make a mess and cause erosion'* (R31P), and *'deer cause more damage in the bush; they cause erosion - lots of tracks down into the creek'* (R23P).

Social

Human safety from wildlife interaction

Considerable concerns over deer-vehicle collisions (DVCs) emerged in the qualitative analysis. A number of residents in the Nariel Valley reported that they had experienced collisions or near misses with deer. Serious injuries and significant financial costs for repairs to damaged vehicles (exceeding $8000) from incidences of DVCs were reported by some respondents. Many believe that '*deer on the side of the road are becoming a serious problem'* (R14P) and that 'y*ou have to keep your wits about you when driving… they are a traffic hazard'* (R17L). One respondent was highly concerned about deer on the roads, stating that: *'it's not a matter of if, it's a matter of when; one day someone will be killed by hitting one (deer)* (R5L).

Recreational hunting

Many landholders were concerned about the promotion of hunting in the district. One respondent identified this as an issue by stating that:

'*The promotion of hunting in the Nariel [Valley] by certain members of the community has increased hunting… I don't like the promotion of hunting in the Valley'* (R26P).

All of the study respondents agreed that hunting in the Nariel Valley has increased in recent years, and it was evident that they regarded the promotion of hunting as a significant factor in this. One landholder explained that, *'we used to see lots of cars parked at the bridge for fishing, but now it's all hunters'* (R28P).

From the interviews, it was revealed that many within the community regard the hunters as a bigger issue than the deer. Sentiments echoed by many included that:

'*I would like to see the hunters go, not the deer'* (R9L).

'It's the flaming deer hunters that are the problem not the deer' (R13P).

'Hunters breed worse than deer' (R32P).

'It's not so much the deer, but the hunters - city folk with a gun and shooting licence but no idea' (R26P).

A commonly held view expressed by many respondents was that deer hunting is not adequately controlled, and that more regulatory measures are needed to appropriately manage hunting. Hunting was seen by many to be an 'intrusive' activity in which 'outsiders' who are armed with high powered rifles, and who have little understanding of the conventions of rural life, come into the district and engage in an activity that is disruptive and potentially dangerous for the local residents.

Indeed, many respondents expressed a fear of hunters and the hunting culture. With a perceived increase in the number of hunters coming into the district and perceived lack of adequate regulation of the sport, some respondents admitted to no longer feeling safe when they go into the bush. One said that '*the presence of hunters has changed the way I use the bush'* (R5L). Another (R9L) reported that they haven't actually seen many deer but have hunters coming into the bush behind their property, which makes them feel '*uneasy*' and '*worried',* and as a result they don't like their children going into the bush unsupervised. Some felt so troubled by the lack of regulations over hunting that they believe '*there will be [human] deaths'* (R23P) if recreational hunting is not managed better.

Hunters' conduct

Serious concerns were expressed about the conduct of some hunting groups. Many reported that some hunters (from out of town) have '*attitude*' and are often '*arrogant*'. One landholder explained that:

'Often the hunters come and camp, and have parties which are offensive and intimidating… I am not comfortable with deer hunters coming to my door to ask to hunt, it can be intimidating' (R32P).

Others reported that hunters often accessed their land without permission, and that there had been occasions where confrontations had occurred when asking hunters to leave. One respondent reported confrontational encounters with deer hunters, which resulted in guns being pointed toward them (R23P).

Another serious concern raised during the interviews was how close some hunters were coming to landholders' houses. One respondent said: '*it's too close for comfort (hunting) – next there will be a bullet in the house'* (R34L). This same person reported that only a week before they were interviewed as part of this study, some hunters had shot and killed a deer in the river 50 m from their house. The carcass was left in the river and the incident was

reported to the local police. This shows the close proximity to residential properties in which some hunting activities are occurring in the Nariel Valley.

Disposal of deer carcasses

Many landholders interviewed in this study echoed the concern regarding deer carcasses being left in the bush by hunters. Three main issues were identified, these being:

1) Carcasses left by hunters could lead to an increase in the wild dog population from the increased and easily available food source.

'*Leaving the carcasses is the worst thing – it's wasteful, and it increases the dog population… there should be a policy – you got to take the whole lot (carcass)'* (R14P).

2) Deer meat should be utilised.

Many were concerned for the apparent lack of respect for the animal and the wasteful nature of the activity, especially when they are killed solely for their 'trophy' antlers. This is indicated by the following statements from some respondents:

'I'm not happy about hunters leaving carcasses – they should take the meat' (R34L).

'*It's got to the stage where blokes are leaving them (deer), beaut meat shouldn't be wasted!*'(R23P).

'Hunters that don't utilise the meat, well it's criminal!' (R1L).

3) Deer carcasses left near, or in, creeks could lead to contamination of the water supply.

The Nariel Creek and its tributaries which run through the valley supply drinking water to residents of the valley and the town of Corryong. One respondent explained:

'Carcasses left in the creek are a problem because they could contaminate the water which people pump from' (R34L).

Illegal activities

Among the study respondents, many reported incidents of illegal hunting on their properties. These included actions such as: illegal spotlighting, stock being mistakably shot by hunters, and trespass. It was evident from the interviews that the activities of some hunters are leading to heightened tensions between some landholders and hunting groups.

Some respondents are becoming more opposed to hunting due to the apparent disregard for the rules displayed by many hunters. One respondent explained that, *'It's a real pain when hunters come onto your property'* (R5L) with another explaining that they have had to lock the gates to stop hunters entering the property without permission (R26P).

Others now feel that '*poachers*' and '*illegal spotlighting is becoming the biggest problem'* (R26P, P23P), with a few landholders reporting stock losses from what they believe was a hunter misidentifying their target. Some examples of such comments by Nariel Valley inhabitants include:

'We had a Ram shot and butchered up the back of the property and we believe that it was a hunter that did it' (R9L).

'I believe we had a heifer shot by hunters' (R26P).

'We have had 8 – 10 cattle shot by hunters in the last year' (R36P). This incident was not on their property in the Nariel Valley but on a property nearby. However, the respondent was concerned that this could happen in the valley.

While respondents reported issues with recreational hunters, many were allowing friends and family onto their property to hunt. It seemed to be the hunters who access private property without permission that frustrate landholders. For example, one landholder stated that he allows 3-4 groups on to his property to shoot deer, but would probably have around half a dozen that come onto his property without permission (R24P). Another local landholder reported hearing gun shots on his property when he had not given permission for anyone to be there (R28P).

Another concern raised by a respondent was the proprietary attitude held by some hunters. A hunter had told this particular landholder that they '*had a place in the Nariel Valley'*, by which they meant a place where they could hunt, not a place that they owned. The respondent '*was surprised with the sense of ownership deer hunters have over my property'* (R32P).

Impact on farm productivity

Some respondents felt that recreational hunters sometimes indirectly affected farm productivity. For example, one landholder explained:

'*We have to pick our time when we go on holiday so it doesn't coincide with peak hunting times because if shooters are about the cattle get spooked… hunters have spooked cattle in the past which causes damage to fences and injury to the cattle. We had a cow dislocate its back hip, when hunters were here – without permission or our consent… It takes time and effort to quieten the cattle and get them used to you, then the hunters come along and spook them which can cause a temperament change… after a long weekend we have to clean up the aftermath* (R32P).

As the respondent above reveals, recreational hunters can cause indirect effects on farm productivity by disrupting farm activities. This can result in incurred costs at the expense of the landholder to rectify the problems.

Desired Deer Abundance

Respondents were asked to indicate whether they would like to see the deer population in the Nariel Valley increased, maintained at the present level, or reduced, and they also were asked to explain their reasons for their response. Their views were varied; however, the dominant attitude (56 % of respondents) was in favour of a reduction in deer numbers. The following outlines the main reasons that were identified by the study respondents as factors influencing their attitude to a preferred population size of deer.

Reduced Deer Abundance

The study respondents who wanted a reduction in the local deer abundance considered deer to be an invasive species that is causing damage to the natural and agricultural environment. Many of these respondents viewed deer as an emerging pest animal threat, and believe that the population is too large. For example, some commented that: *'I have seen substantial increases; they are now at plague proportions* (R8L); and '*there is an endless supply of them, you kill one and four will turn up'* (R36P).

The majority of the study respondents who wanted a reduced deer population were primary producers or landholders who had experienced what they perceived as negative impacts from deer. However, while many wanted to see deer reduced, the desired level of reduction varied.

Some landholders wanted to eradicate deer, as evident in the following statement: '*I would like to see deer completely removed because they are non-native and do too much damage. It would be better as a farmer to see them completely removed* (R25P). However, it was generally acknowledged that eradication would not be achievable without a significant expenditure of time and money, and the practicality of reducing such an elusive and well-established species in remote country would be difficult:

'*Complete removal would be something to aim for but it's never going to happen – it's not possible to eradicate them now'* (R29P).

'*There is no way that we will get rid of them all, they are well established now'* (R20P).

Some other respondents wanted deer to remain in the bush but at a reduced level; '*I certainly don't want them (deer) removed completely but I would like to see the numbers slightly reduced* (R8L).

Many people in the Valley recognised that deer populations are increasing rapidly and want to reduce the population increase. One respondent stated that, '*there are definitely plenty out there!'* (R31P). A slight or moderate reduction in the deer populations is wanted because, while deer are not a major problem at present, they could become a problem if their abundance is not reduced: '*I would like to see the population moderately reduced – I don't think that deer are causing too many problems yet, but I have family members that have very different opinions about the deer* (R19P).

The size of the deer population has economic consequences for producer landholders as '*feeding approximately 50 head of deer every night has an impact on farm profitability'* (R10P).

While many landholders would like to see the deer numbers reduced, they didn't always want the same population level for each deer species; '*I would like to see the population greatly reduced… not so much the sambar deer, but more so the fallow deer because they're breeding up now'* (R20P). This means that it may be important in understanding stakeholder

attitudes to deer to clarify which particular deer species individual landholders are concerned about.

Maintained or Increased

In contrast to the previous group of study respondents, there were some who stated that they want the deer population in the Nariel Valley to be maintained at present levels or increased. Most of these respondents were lifestyle property owners who had not experienced any perceived negative impacts due to deer. Of these, many wanted '*to see the population remain for hunting'* (R7P) and *'for future generations'* to enjoy (R31P). Other respondents held concerns regarding animal welfare and animal rights issues, and didn't want to see the destruction of any animal, be it native or introduced: '*I love all animals equally and don't want to see any animal killed* (R12L).

Population Management Methods

Landholders were asked what control techniques they use to manage deer and to indicate which management strategies they would find acceptable to reduce deer populations. The following section details their responses.

Current Control Techniques

The study respondents who stated that they were already managing deer on their property were all primary producers. The methods that they used were ground shooting and spotlighting. Some landholders hunt deer to manage the population levels as well as a form of recreation. Others see it as a job that needs to be carried out: '*it's not really recreation, it's part of my job - I shoot deer once a month in an attempt to keep numbers down'* (R25P).

Generally, landholders reported a high success rate of killing deer. One respondent stated that, *'I control deer on my property by shooting about once a week, there's probably only been once where I haven't been successful in shooting one (deer)'* (P29).

Many of these landholders also allow recreational hunters onto their property to control deer. These landholders explained that by doing so it '*helps to reduce deer proliferation*' (R10P). This method was popular amongst respondents because it is a cost-effective way of managing the deer population.

The respondents who were undertaking deer management all felt that the deer were having a negative impact on their farming business. In contrast, respondents who were not controlling deer tended to feel that there was no need to because deer do not damage their property, or because they benefited from control by neighbouring landholders: *'[my] neighbours shoot them'* (P24 & P13).

There was however recognition by some local landholders that, whilst they do not control deer *yet*, they may need to in the future. For example, one respondent stated that, *'I don't control deer on our property besides allowing friends to come in occasionally to hunt deer, but it's getting to a stage now where we might have to start to control deer'* (R32P).

Acceptance of Management Strategies

Respondents were asked about their attitude toward a range of management strategies to control deer abundance. Most (97%) accepted the need for control but favoured some techniques over others. Farmers tended to be more pragmatic about control compared with lifestyle property owners. Most respondents however realised that: '*no management intervention is not an option'* (R8L). Some (15%) thought the government was too slow in implementing management, stating '*we are behind the eight ball by 20 odd years'* (R25P).

The following outlines the control techniques discussed and respondents' general responses to each technique.

Game meat harvesting

Game meat harvesting was widely accepted as an appropriate deer management approach. They liked the idea that deer could be utilised as a resource. Many believed that *'there's a market for wild deer meat'* (R31P) and that *'deer are going to become a pest, so why not do something smart about it? It's a niche market – we could sell the meat* (R23P).

While the majority (37 %) thought game meat harvesting would be a good management strategy, there was some concern among other respondents that it might not adequately manage deer. Some were concerned that, if an economic benefit was derived from wild deer meat, there would be an incentive to see deer populations in the wild maintained or increased. One respondent explained: '*I'm not keen on game meat harvesting because then people would want to see the population sustained* (R25P). This concern was justified by another

respondent's statement that, '*If deer were not going to cause too much damage to the bush, and became a viable business then I'd like to see deer populations maintained*' (R23P). This supports the perception by some that the strategy may be compromised if an economic gain were to be derived.

Recreational hunting

Recreational hunting was widely accepted (31 %) as a management strategy. Recreational hunting is currently the only strategy used to manage deer in Victoria. While many accepted hunting as a control method for deer, they were concerned about how hunting was being regulated: '*It (hunting) needs to be controlled better… the system needs to be sorted out so innocent people aren't killed'* (R23P). Others were concerned about the carcasses left by hunters: *'I support recreational hunting as a control method but would like to see carcasses removed'* (R15P).

Many recognised that recreational hunting is not an adequate method when used in isolation and it needs to be used in conjunction with other deer control methods. One landholder explained: '*Recreational hunting nearly works as a control method but it's not a standalone technique'* (R14P), while another explained that they think recreational hunting is an acceptable method but they understand that '*hunters couldn't kill them all'*, and that *'it doesn't go far enough*' to control the population (R25P). Others noted that recreational hunters often are only after a trophy stag. By only targeting stags, recreational hunting does little to reduce the population: *'it needs to be in balance, you need to kill a hind for every stag'* (R31P).

Some thought that hunting could be economically beneficial if people were willing to pay for the privilege to hunt deer '*If people were willing to come and pay to shoot a deer then that could become an asset'* (R23P).

Whilst many accepted this strategy, some respondents were opposed to this approach. They felt that the valley could become over-run with hunters and they were '*not keen on the government promoting hunting in Victoria'* (R15P). Some felt that the promotion of hunting in the Nariel Valley had already increased hunting to undesirable levels (R26P).

Poison

There was a clear rejection (95 %) about the use of poison as a management technique. The main concern about the use of poison was the risk to non-target species, and the perceived in-humaneness of the technique: *'I don't like poisoning as a control method, it's inhumane – they don't need to suffer'* (R5L).

Trapping

Only a few accepted trapping as an appropriate deer control approach. They said that trapping would be difficult to undertake and many were concerned that it could be inhumane because it could cause injury to the animal and would not be effective for reducing deer populations. Many were pragmatic about this option and didn't think it was a viable strategy because '*deer are far too cagey to be trapped'* (R25P).

Other techniques

While respondents supported a number of techniques, only few (3 %) thought that the best way to manage the emerging issue of deer as a pest animal threat is to implement a targeted, systematic, landscape-scale approach managed by state agencies such as the Victorian Department of Environment and Primary Industries. These respondents stated that '*I would like to see an outright cull – managed humanely'* (R25P) and '*I believe the best way to control deer would be through a targeted controlled shooting program, carried out by a department like DEPI so they shoot hinds not just the bucks'* (R26P).

DISCUSSION

Wild deer abundance in the Nariel Valley appears to be high with considerable evidence of ecological damage caused by deer (Ch 3). However it is not clear what may be the social implications of having a relatively high abundance of deer in the valley.

It is important to understand the human dimension of wildlife management in order to develop appropriate management strategies (García-Llorente *et al.* 2008). Social effects however can be much harder to quantify than environmental impacts (Ford-Thompson 2011). Before a management strategy can be developed that addresses social issues, there must be answers to a number of questions, including: How are wild deer perceived? How are landholders affected by deer? And how would landholders like wild deer populations to be managed? (adapted from Miller 2003).

This research aimed to identify attitudes of local landholders toward wild deer and attempted to identify factors that influence people's perceptions of deer (both in a positive and negative sense). The research also aimed to identify options for managing deer and the likely attitudes of the local landholders to the application of these techniques. This research, together with findings from other studies (e.g. Finch and Baxter 2007; Ford-Thompson 2011), provides an important initial step in understanding community attitudes to wild deer management and may help in the development of a management approach that responds to landholders' concerns and attitudes.

This study did not examine respondent characteristics such as: age, sex, income etc. Instead this study aimed to identify situational factors, such as experiences, and perceptions that may influence landholders' attitudes toward wild deer management. Although the results from this study may be specific to the landholders in the Nariel Valley, it is likely that similar attitudes may exist among landholders in areas with comparable habitat and deer populations.

Furthermore this research focused on landholders and residents in the Nariel Valley as they are a group currently being affected by a growing population of deer; there was no attempt to survey external stakeholders during this pilot study.

The quantitative and qualitative analysis showed that there are three main dimensions to local attitudes towards deer: awareness, perceptions and management, with specific themes and sub-themes within these dimensions. Quantitative data supported the qualitative data,

although responses during interviews revealed that simple categorical response options do not adequately answer the research questions.

Awareness

The level of awareness that landholders have regarding invasive species, such as deer, has been found to influence public attitudes and perceptions. Where landholders have an awareness of invasive species and their damage, management programs tend to receive a higher level of public support (Bremner and Park 2007).

The level of awareness among landholders in the Nariel Valley regarding deer and their impacts was reflected in the quantitative and qualitative results. All landholders surveyed were aware of deer in the Nariel Valley. The majority of landholders (94 %) reported having deer on their property either sometimes or always, indicating that deer/ human interactions are high. Most respondents reported that they became aware of deer during the last ten years. At the extreme ends, some landholders have been aware of deer for 30 years or more, whilst others have only become aware of deer in the last two years. This result was largely influenced by how long the person had lived in the valley and how they used and interacted with the environment. Producers tended to have been aware of deer in the valley for a longer length of time. As producers spend long hours working on the land, their encounters with deer are likely to be higher than those that spend little time outdoors or in the bush. As well as time spent outdoors, primary producers are more likely, than other types of residents, to be at home on their property rather than only intermittently present.

Many landholders feel that the deer population is increasing as opposed to stable or declining. The consensus of the respondents is that the increased deer abundance in the valley is a comparatively recent phenomenon. The long-term and full-time residents, in particular those who are primary producers, tended to have a greater awareness and understanding of the damage associated with deer. These residents have seen changes to the environment as deer populations have increased and as a result, typically are more aware than short-term residents of the damage and impacts that deer have caused in the valley.

Lifestyle property owners and those that were relatively new residents to the valley had limited awareness of the impacts of deer. Ecological field work conducted on the boundary of the Nariel settlement, where most of the lifestyle properties are, indicated that there was substantial deer activity which was causing damage to the bush, including trails, wallows,

rubbing and browsing. With the exception of one landholder in the settlement, residents did not believe that deer were causing any impact on the bush. In one case, the resident had a significant wallow (see Figure 3.10: C) approximately 50 metres from his rear boundary, yet was unaware of it and the associated damage that deer had caused in the damp gully where it was located. This limited awareness of the damage that deer cause may reduce people's acceptance and willingness to support management strategies (Bremner and Park 2007), especially since a number of the residents in this small community saw the deer as being 'beautiful' and responded to them in an anthropomorphic way.

Despite this, people tended to have an abstract understanding of the potential for deer to cause damage. Many lifestyle property owners were aware that farmers were being affected by deer coming onto their properties and causing damage but, because these effects did not directly impact on them, the lifestyle property owners did not perceive the damage as important or significant.

There was no consensus among the primary producers as some saw deer as an immediate problem whereas others recognised that they could become a problem if the populations kept increasing but were not a problem as yet.

When developing management strategies, it is important to understand the level of awareness landholders have regarding wild deer. Where awareness is limited, the management strategy should include informing and educating landholders as an ongoing process so as to enable people to make informed decisions (Jackson 2001). This will encourage higher levels of public support and participation in management programs.

Perception

The management of wild deer is problematic because conflicting perceptions of people regarding deer can create barriers to effective management (Witmer *et al.* 2009). The range of perceptions is largely influenced by people's different experiences with deer and the subjectivity of their understanding of impacts. Some impacts may be considered positive by some and negative by others. For example, a reduction of understory vegetation may be perceived by some people as a means of reducing fuel loads whereas others may see it as destruction of the flora ecology.

Impacts are subjective, being described by Decker *et al.* (2002) as 'wildlife-related effects that the stakeholder recognises and regards as important'. Understanding the varying

perceptions helps managers to define the problem and determine appropriate objectives. Qualitative analysis of the interview data revealed that responses to interactions with deer varied among the respondents, and appeared to be largely shaped by economic, social and environmental effects.

Many effects are caused by deer, yet many go unnoticed. Those effects that are recognized by landholders and are perceived as being important are the effects that people perceive as either positive or negative impacts (Decker *et al.* 2002). Landholders can have a different assessment of a single experience with deer, which may generate both positive and negative impacts (Decker *et al.* 2002; García-Llorente *et al.* 2008). This will largely depend on how the individual weighs the importance of each effect. For example, lifestyle property owners were more willing to accept damage on their property from deer because they felt the aesthetic value of the deer outweighed the damage they caused on their property, whereas producers were less tolerant of deer on their property because the economic impact outweighed the aesthetic benefit.

Perceptions provide a strong indicator of the likely support for management strategies (Sharp *et al.* 2011a). Where perceptions of an animal are mostly positive, support for management will be low (García-Llorente *et al.* 2008). Therefore understanding or knowing the range of perceptions is important when assessing the need for appropriate types of management (Ford-Thompson *et al.* 2012). However, management strategies and priorities alone are not likely to shift people's perceptions of an animal (Ford-Thompson 2011).

Perceptions are influenced by many factors, including demographic, social and cultural factors (Witmer *et al.* 2009). Perceptions were found to vary greatly between lifestyle landholders and producers in the Nariel Valley. Lifestyle landholders typically held positive perceptions of wild deer, seeing them as either an iconic species or one that had specific aesthetic merit. Producers however were more inclined to perceive deer negatively. Conflicts are more likely to arise where there are different perceptions regarding wild deer.

The following sections outline the main effects which influenced landholder's perceptions of wild deer.

Negative Perception

Negative perceptions of deer were found to be largely influenced by economic (impact on farm profitability), social (hunting culture and safety issues) and environmental (threat to native vegetation and conservation) effects.

Many respondents that had negative perceptions of deer had suffered a financial loss directly or indirectly due to deer; e.g. loss of pasture, damage to fences, disruption of animal husbandry due to hunting activities and deer-vehicle collisions. The most common impacts reported were economic, in particular diminution of land function - including reduced profitability of businesses and damage to the bush and cultivated environment. These impacts have been reported in other parts of the State. Lindeman and Forsyth (2008) attempted to quantify the economic impact of deer on production. Based on surveys with landholders they estimated an annual average cost of $4600, but the estimates ranged anywhere from $200 up to $20 000 per individual producer (Lindeman and Forsyth 2008). When landholders, in particular primary producers, feel that the productivity and profitability of their land is being directly affected by deer there will be more support for management programmes to reduce the population and associated impacts (Bremner and Park 2007).

Negative perceptions were not only related to financial costs; some landholders expressed concern regarding environmental impacts. Observations by some landholders identified a range of impacts which they see as a matter of concern. These include changes to vegetation structure, erosion from trail formation, and impacts on water quality.

Furthermore negative perceptions were influenced by social effects, namely safety concerns relating to deer/vehicle collisions and recreational hunting. These types of social concerns are not unique to the Nariel Valley and are identified as common effects which are experienced when deer populations are abundant (e.g. see Clayton *et al.* 2003; Ford-Thompson 2011).

'Human-human conflict'

A sub-theme related to negative perceptions that emerged was 'human-human conflicts'. Conflicts relating to wildlife management are increasingly recognised to be between people (Ford-Thompson 2011). In that there is social disruption as people take opposing sides in relation to management of an animal species. This is most common where incompatible and divergent values and perceptions of different stakeholder groups result in conflict.

The main source of human-human conflict encountered in the Nariel Valley was due to recreational deer hunting. Whilst landholders recognise that it is only a minority of hunters that are a problem, considerable concern regarding the conduct of hunters in general was clear from the qualitative data analysis. The behaviour of some hunters is having an impact on the credibility of the wider shooting fraternity because some are either breaking the law or not observing the conventions of hunting by seeking permission to hunt on private land (Martin 2009). This is substantiated by the results from the qualitative analysis which revealed that many landholders have experienced negative experiences associated with recreational deer hunters. Many landholders expressed concern regarding their personal safety and felt that the current regulations need to be reassessed in order to provide better protection to the community. These are legitimate concerns as there have been fatalities due to recreational hunting, where both hunters and a bushwalker have been killed in Victoria.

However, with recreational hunting being touted as the second biggest tourism money earner for the Victorian State Government, human-human divisions are set to deepen as deer numbers increase and hunters increase (Martin 2009). Victoria's Economic Impact of Hunting report (2014) suggests that the hunting industry is worth $439 million. As a result of the significant revenue generated from recreational hunting, the Victorian Government is actively trying to promote hunting in the State. There is potential for conflict between people in support of hunting and those opposed. This is likely to cause considerable conflict, as this Nariel Valley study revealed that hunting, as it is currently managed, is causing considerable negative socio-economic impacts to many within the local community. The emergence of conflicts between landholders and hunting groups is already occurring and is likely to increase without further consideration into how these activities are managed.

When conflicts such as these are managed inappropriately by wildlife authorities there is an increase in the likelihood of conflicts between communities and wildlife authorities. Conflicts between communities and wildlife authorities are particularly detrimental to the management of invasive species, because if there is a break-down of relationships between the two groups then public support will diminish (Ford-Thompson 2011).

Additionally human-human conflicts may arise between wildlife authorities and landholders if the deer population continues to increase. Landholdings in the Nariel Valley are surrounded by public land, the management of which is the responsibility of State government agencies. If landholders start to feel that there is an unacceptable number of deer coming from public

land onto their properties, they are likely to shift their frustration to the public land managers because they have not adequately controlled the deer population. This pattern of behaviour is well-established as shown by the default criticism of public land managers in relation to the control of feral species that appear to come from public land holdings such as wild dogs, foxes, goats, pigs, blackberries etc.

Positive Perception

Support for management will be increased if management reduces the impacts discussed above. However consideration must be given to the positive perceptions of wild deer, because management focused only on negative perceptions may impact on landholders who like deer, and will lose their support (Decker *et al.* 2002).

Invasive species are not always perceived negatively because they may also have positive impacts. These include economic benefits, through provision of employment opportunities, recreation, such as hunting, and an aesthetic value (Pimentel 2002). This was evident from the testimony of people who lived in the Nariel Valley. Positive perceptions and attitudes to deer were largely influenced by perceived economic, social and cultural (aesthetic and anthropomorphic) benefits derived by the community.

The characteristics of a particular species, including size, attractiveness etc. has been found also to influence people's perceptions of the species (Reading and Kellert 1993). This is substantiated in this study, with people perceiving deer positively due the aesthetic benefits they provide. There was a dominant attitude among people that perceived deer positively as 'beautiful creatures' and 'pretty little things'. Research by Ford (2008) also found that the aesthetic value of deer in the Royal National Park was an important influence on people's level of support. Ford (2008) suggests that aesthetic value is a strong motivation for non-participation in deer management programmes.

Additionally some landholders expressed a cultural association with deer. Deer have value for those who believe that they have cultural significance or are perceived as an asset. This suggests that in a relatively short period of time, people are able to develop a cultural association with an exotic animal, such as deer. As a result people value that animal for the continuation of their cultural activity.

Although positive perceptions of deer were not held by the majority of landholders, it is important that management recognise the benefits that people perceive deer have. By acknowledging these positive perceptions management plans can be developed in consideration of all view points and this may limit future human-human conflicts (Ford-Thompson 2011). For example, management could aim to manage deer at levels at which negative social and ecological impacts are reduced but positive effects can still be obtained.

It is important to note that a range of factors including education, knowledge and understanding were not explored in this study so it is hard to say if these were additional influencing factors. Further research into these aspects would be useful.

Management

There are different attitudes and levels of acceptance to methods of control (Ford-Thompson 2011). Studies of attitudes towards the management of so-called problem wildlife reveal that acceptance of strategies varies, depending on the species of animal (McIvor and Conover 1994). Some animals are regarded with greater respect than others; for example, horses and deer compared to pigs, foxes, wild dogs etc. This is because horses and deer are charismatic and usually non-threatening and so there is a substantial amount of cultural anthropomorphism about these species (Nimmo *et al.* 2007).

Deer control is further complicated because in the State of Victoria the laws relating to the management of deer are contradictory. On one hand, deer are classed as a game species and therefore have a measure of protection as a recreational hunting resource. However, on the other hand, sambar deer are listed as a potentially threatening process to native biodiversity. Sambar deer are likely to be the most abundant species of deer in the Nariel Valley.

The challenge is to develop management strategies that achieve social and ecological outcomes that are appropriate, effective and acceptable to the community and that accommodate the diversity of awareness, perceptions and attitudes within the community. The diverse range of views about deer and their management and the contradictory State legislation indicate that this will be difficult and will likely require extensive consultation, time and compromises from stakeholder groups (Ford-Thompson 2011).

The central problem is that any animal that is given 'game' status is managed to 'provide continued, sustainable hunting opportunities' and there is no attempt to eradicate or reduce the populations of the species. The declaration of deer as a game species thus proscribes the methods of control that are permitted but arguably does nothing to actively manage the deer population and their impacts. This has created a situation where some people in the community are disappointed that the government has allowed what they see to be a pest species to proliferate. As one respondent reflected the government is twenty years behind the eight ball.

Best practice management of a pest species should employ a strategic approach to reduce the damage caused by the pest (Braysher *et al.* 2011). This strategy would require specified outcomes, a coordinated approach to reduce damage and an ongoing monitoring program to assess and evaluate the strategy. However, as deer remain listed as a 'game' species there is no attempt to manage the populations in the state of Victoria in such a manner.

If deer were declared to be a pest species then the control options would be greater and land managers would be able to control this species with fewer restrictions.

Pest Status

A pest animal is defined as '*those animals that cause more damage than benefits to human-valued resources and social wellbeing'* (Braysher *et al.* 2011, p.301).

A pest is a human construct, what may be a pest to one may be a valued resource to another. Therefore it is important to understand how landholders perceive an animal because this has implications for the success or failure of a management program (Braysher *et al.* 2011).

The majority of the respondents believe that deer should be declared a pest (64 %); however there was still a significant proportion (36 %) that was not in agreement. This contradiction may be representative of attitudes in rural areas where deer are present. A survey of Queensland landholders found similar results with landholders divided in their response to pest declaration, with only 42.9 % *for* and 57.1 % *against* (Finch and Baxter 2007). However Finch and Baxter's Queensland (QLD) study found regional differences, with some regions more in favour of pest declaration than others (Finch and Baxter 2007). These results suggest that there are difficulties in obtaining consensus within the community that deer should be declared a pest species. Despite this division in public opinion the QLD Government has

recently declared deer to be a pest species, showing that with political will, such community opposition can be overcome or ignored.

In the Nariel Valley, two reasons were given by respondents to justify the declaration of deer as a pest species. These were because deer cause economic damage to farming operations and cause damage to the bush. Producers have a vested economic interest in the production of crops and pasture, and incursions by deer are seen as damaging to their business. As one respondent put it "*I'm in the business of farming cattle not deer*". Lifestyle residents have typically come into the valley because they were attracted by the natural beauty of the area; those of this group that wanted to see deer declared a pest did so because they were aware of the damage that deer are causing in the bush.

It is clear that there is no obvious agreement among landholders whether deer should be declared a pest species. However, deer hunters (who were not interviewed in this research study) are likely to be opposed to such a course of action. The crux of the issue is that if deer are declared a pest, hunters may feel that their recreational asset is being devalued and threatened (Martin 2009). At one level, the Victorian Government sees deer as a valuable resource which generates significant revenue, so it is unlikely that deer will be declared a pest species and have removed the protection that game species status provides. The potential political tensions are obvious, because as the deer hunting community grows, and yet possible impacts increase and compound, there is likely to be a corresponding increased effort to exert political pressure. This pressure will come both from the hunters and associated vested interests; for example hunting and camping retailers, publishers of hunting magazines etc. In order to understand the tensions that exist in the management of this species the hunters' point of view will need to be taken into account in conjunction with other interest groups.

Pest declaration may help to facilitate management programs but without comprehensive policing of the requirement to control a pest species the pest declaration has no meaningful effect. Unless all land managers, and that includes private and public land holders, engage in a strategic campaign of management, there can be no confidence that pest declaration will achieve an effective, land-scape scale reduction of the species.

Desired Deer Abundance

Invasive species can have both positive and negative impacts. Where they are perceived positively, there is a greater level of tolerance for effects associated with the species (Decker *et al.* 2002). As many landholders were in favour of the population remaining at current levels or increasing (44%), it would appear that the effects caused by the current deer population is not being perceived as overly negative. This attitude reflects those of landholders in New England NSW ten to fifteen years ago in relation to deer. According to a report broadcast on ABC Radio National, landholders in this region were unwilling to let hunters shoot deer on their properties because they felt deer were 'pretty little things' and 'little Bambis'. However with an increasing deer population this view has changed. Many farmers now report that they feel besieged by deer and are now more willing to allow shooters onto their property in order to manage the growing problem (Martin 2009). This could be an indication of what is likely to occur in the Nariel Valley if the deer population continues to grow to such an extent that all landholders are negatively affected by their activities.

When the benefits associated with deer are outweighed by the damage that they cause landholders will be more willing to support a reduction of the population (Decker *et al.* 2002). In general, primary producers were found to experience more damage associated with deer than lifestyle property owners and so were less tolerant of the species. Producers have been found to have a lower cultural carrying capacity than other landholder groups (Zinn *et al.* 2000). Cultural carrying capacity is defined as 'the maximum number of animals that can compatibly co-exist with a local human population' (Ellingwood and Spignesi 1986 as cited in Zinn *et al.* 2000)

One of the questions in the survey was 'what population level you would like to see for deer in the area'. The responses indicate that this question was problematic, because people's perceptions of the deer populations were very different. Some stakeholders in the valley consider the deer population to be overabundant because they are causing social, economic and environmental impacts. However the notion of overabundance is fundamentally subjective and is likely to be based upon a range of values, experiences and knowledge (Garrott *et al.* 1993). Therefore when developing a management plan its focus should be on minimising damage, rather than focusing on simply reducing the numbers of the pest species (Braysher *et al.* 2011).

Control

Because people value and perceive deer differently, there are differences in opinion in regard to how, and even if, management should be implemented (Ford-Thompson 2011). People's responses to proposed management and control techniques are likely to be influenced by their perception of the value of deer. This will have a fundamental effect on whether they will support management strategies or actively lobby against them (Bremner and Park 2007). This presents challenges for wildlife managers who will also be subject to political as well as social and ecological imperatives (Decker *et al.* 2002).

The success of wild deer management will largely depend on whether the control methods are regarded as acceptable to local landholders. Sharp *et al.* (2011b) believe that management will be accepted if it is seen as being humane and justified. This is theoretically true but the results obtained in the surveys conducted for this research indicate that there is no single justification for the control of the deer that is shared by all respondents. Although all the respondents, with the exception of one, agreed in principle that deer should be controlled if they became overabundant. But as discussed earlier the idea of overabundance is entirely subjective. This is particularly difficult in the case of landholders who do not distinguish such exotic animals from native animals.

Because the question in the survey was proposed as a hypothetical it can only provide an indication of which strategies would be acceptable if there were agreement that the population was too large and required culling.

The majority of landholders did not have objections to lethal control. Studies reveal that rural landholders are more likely to experience conflicts with wildlife and so are more likely to welcome such methods, whereas people with lower vulnerability to impacts associated with the pest species are more likely to object to lethal control (Treves and Naughton-Treves 2005). This was also supported by this study which found lifestyle property owners to be less supportive of lethal control.

The two most favoured control techniques were game meat harvesting (38 %) and recreational hunting (31 %), whereas the least favoured were trapping (3 %) and poisoning (5%). Fertility control was only marginally accepted (19 %). These results indicate that there may be support for control where the target animals are humanely killed and the carcasses utilised. Few of the respondents in this study chose no management as an option and few

thought that other control techniques needed to be employed i.e. government controlled cull. The acceptability of these techniques was mirrored by rural QLD landholders surveyed by Finch and Baxter (2005). The similarity in results may reveal a broader view regarding acceptability of management techniques.

The success of any control program will largely depend on the degree of acceptance of the control methods by the community (Axford and Brown 2013). Landholders generally accepted game meat harvesting and recreational hunting as a means of control however there were some concerns expressed regarding these techniques. It was felt that hunting may not be a completely effective means of population reduction, may not be humane and that uncontrolled hunting would affect the social amenity and safety of residents in the valley.

These concerns correlate to the three main characteristics that have been found to influence public attitudes and acceptance towards control methods (Fraser 2006):

- Specificity - The ability of the control method to act specifically on the target species.
- Humaneness – The quality of death
- Degrees of uncertainty – Public perception of the risk associated with the control method (environmental, economic and social)

Where there is a failure to meet these three criteria there is a reduction in the acceptability of the methods.

Additionally the acceptance of management strategies can be influenced by the nature of the damage caused by deer (Reiter *et al.* 1999) and the demographic characteristics of the individual (Sharp *et al.* 2011a). When impacts are considered severe there is more willingness to accept more controversial control techniques (García-Llorente *et al.* 2011). For example where impacts from wild dogs are considered to be severe, control often involves the use of 1080 poison. The Nariel Valley has populations of wild dogs which are poisoned by the Department of Environment and Primary Industries with 1080. There is apparently minimal opposition by the landholders to this form of control for wild dogs. This could suggest that the impacts associated with deer are not considered great enough to support the use of such methods; however support for poison may increase in the future if the damage due to deer activity increases and people are provided with sufficient information to allow them to understand why such a course of action is necessary.

Many respondents accepted recreational hunting as a management strategy; however Nugent and Choquenot (2004) found that game and recreational hunting are the least cost-effective techniques for controlling deer in forested environments, such as found in the Nariel Valley. Nugent and Choquenot (2004), argued that a more appropriate strategy in forested environments would be a targeted State funded control program. In order to reduce a deer population the rate of attrition must exceed the annual natural replacement rate. In order to do this over half of the population of deer would need to be killed each year. This presents a difficult challenge given the behaviour and habitat requirements of deer and the current low support for deer control. While many recreational hunters believe that they can reduce the growing population (Martin 2009) the fact that deer numbers continue to grow indicates that recreational hunting is not able to control the population. This could be in part because many recreational hunters target trophy stags and leave the hinds in the bush to continue to breed (McLeod 2005). What is required is a strategic control program that has set objectives and targets which can be assessed and evaluated in order to determine the effectiveness of the program. Given the ad hoc nature of recreational hunting it is unsuitable as a control method (Booth 2010).

Recreational hunting is favoured as a control technique, but many landholders expressed concern over the 'nuisance impacts' of hunting, such as the presumptuous and intimidating behaviour of some hunters. As a result many landholders admitted to allowing friends and family onto their land to hunt but prohibited access to people that they didn't know. By limiting the people that they allow onto their property to hunt potentially limits the effectiveness of recreational hunting as a management strategy (Decker *et al.* 2002).

It is clear that there are various factors that may influence the acceptance of management strategies. Therefore, in order to develop the most effective and acceptable strategy, wildlife managers will need to engage with stakeholders throughout the development of a management plan. This should include: defining the problem, determining the management objectives, selecting appropriate techniques, implementing, monitoring and evaluating the program.

The animal welfare group RSPCA, states that 'before a control program is developed, it must first be established that it is necessary… With limited information regarding deer abundance it will be difficult to develop effective control programs, therefore further research is needed to establish data on deer abundance and associated effects in order to acquire a sound

understanding of the impacts wild deer have on the natural environment and to provide information to the community to justify the management strategy that has been selected.

Limitations

Although this research included a large proportion of the landowners from the Nariel Valley, it did not include external stakeholders in the analysis. Such stakeholders include recreational users of the area and hunters. This research does not include the perspectives of those stakeholders and therefore there will be important social factors that did not emerge in this analysis but that are important to understand as part of developing an effective management strategy. Further research would benefit from the inclusion of these external stakeholder groups as they will have an important influence on potential management strategies.

Landholders were not provided with additional information about each of the management options. This might mean that landholders were not clear about the details of what each control measure entailed. Further studies could provide respondents with information about each control technique so that a more informed response could be given.

Conclusion

It is clear from the research undertaken for this pilot study that there is no unanimity about the number, impact, significance or value of deer. There is a growing awareness of the presence of deer which is causing people to independently develop opinions about their value, impact and ways in which they are managed. In this highly fluid situation, it is possible that a targeted public awareness program could be developed to assist people to gain an informed understanding of the nature of the issue and how it might be managed. Without such information, it is likely that people will independently form their own opinions and these will reflect their vested interests and be in response to the losses and gains that they feel they are experiencing. The risk is that once this has happened people will affiliate to their own position and it will become increasingly difficult to move them from their independently developed point of view. Development of a control will need to engage all stakeholder parties and this will require them to have a holistic informed understanding of the ecological, social, economic and political issues.

CHAPTER 5 – PRINCIPAL FINDINGS, CONCLUSION AND FUTURE RESEARCH

Principal Findings

The aim of this pilot study was to explore the ecological and sociological aspects of wild deer management in the Nariel Valley. This research aimed to establish preliminary data on wild deer abundance and identify their impacts on the local environment. In addition the study examined landholders' attitudes toward wild deer in order to better understand which factors might influence people's attitudes to wild deer and the management strategies developed to control them. This research has provided valuable insight into the emerging problem of wild deer. Below I present a summary of the key findings related to each aim and discuss the significance of the findings.

1. *Determine an index of relative deer abundance and habitat use in the Nariel Valley***.**

The results from the ecological component of this investigation suggest that the relative abundance of deer in the Nariel Valley is high, with deer activity concentrated in the fringe country. This study did not specifically investigate population dynamics and carrying capacity of the landscape; however given the recent rapid rate of population increase, it is likely that the populations will continue to increase unless an effective management strategy is employed.

The ecological consequences of an increasing population are unknown; however as wild deer were found to be present within all four EVCs in the Nariel Valley it is likely that the impacts would be widespread. Furthermore it is likely that the impacts would be magnified with any increase in population. Survey results indicated that Herb-Rich Foothill Forest and Heathy Dry Forest had the highest likelihood of deer occupancy, whereas Shrubby Dry Forest had the lowest. As the survey work was conducted during May through to August, these results gave a snapshot of the density of deer across the EVCs during the winter months. It is unknown whether this site occupancy changes seasonally. A clearer understanding of habitat use across the year would be needed to enable managers to target deer during the different seasons.

High variation in faecal pellet counts was recorded within each of the EVCs which indicated that vegetation type may not be the main predictor of deer occupancy. Other factors such as access to water, elevation, aspect, the quantity and quality of forage, cover, and proximity to cleared land may be more important determinants for preferred deer habitat.

There is still a lot that is not known regarding the behaviour and habitat preferences of these deer species. As outlined in the principles that underpin best practice management (Braysher *et al.* 2011), management needs to be based on sound knowledge regarding the pest species. This highlights the importance for further research to be carried out on deer in order to obtain the information necessary to effectively manage the growing populations.

2. *Identify those Ecological Vegetation Communities which are most at risk from deer damage in the Nariel Valley.*

This study found evidence of environmental damage caused by deer in all four EVCs, particularly to vegetation and soils. Herb-Rich Foothill Forest and Heathy Dry Forest experienced the most damage due to deer. Grassy Dry Forest experienced the least amount of damage, but this may have been because damage is more difficult to detect in grassland environments. Herb-Rich Foothill Forest and Heathy Dry Forest tended to be located on lower hill slopes where conditions were moister and impacts were more pronounced. These factors may indicate that these EVCs are more vulnerable to deer damage.

As little is currently being done to manage the deer populations, damage to these environments is likely to increase. Long-term implications are still poorly understood in the Australian landscape but judging by international studies it is clear that deer have the potential to cause significant damage to the bush. Impacts such as structural changes, distribution of species and vegetation communities, weed dispersal and erosion may require long-term restoration programs to remediate the damage that they cause. The potentially serious nature of their impacts necessitates concern for the conservation of even those environments that are classified as being of 'least concern'.

Targeted programs are often focused on areas that are classified as vulnerable in order to mitigate effects where they are most deleterious. However the complex topography of the Nariel Valley, with features including ridges, spurs and gullies, makes targeted practical management of such areas extremely difficult. Gullies tend to be moist environments which

exhibit particular vulnerability to impacts by deer. These areas provide critical habitat which is important for a range of flora and fauna, including potentially vulnerable species. In spite of that, a key knowledge gap is the species which utilise these habitats in this area as this can help to establish what species may be at risk. The gullies also perform an important role in the hydrological functioning of this upland catchment, and damage to these areas may have further implications for the associated aquatic environment, not considered here. Any management strategy should consider the subtle complexities of this area rather than being restricted to broad EVC classifications as a proxy for habitat.

3. *Assess the attitudes of local landholders in the Nariel Valley toward wild deer, including their benefits and damage.*

Attitudes towards deer within the Nariel Valley were variable and were largely influenced by people's different experiences with deer. Producers typically viewed deer in a negative light because they suffered an economic loss due to deer damage. Lifestyle property owners tended to see deer more positively, as they felt deer provided an aesthetic, sporting or commercial benefit.

In a small rural community such as the Nariel Valley, which has a mixture of land tenures, the nature of the occupancy is typically based upon different motivations. Primary producers have a production priority so they regard the land as a resource which must be managed to ensure the best economic returns. Any species which competes with their stock is generally regarded as a pest. This applies to native and non-native species. They often have a reflexive response to reduce the populations of any animals which compete with their stock. Lifestyle occupants have a different motivation for living in the valley. Typically their landholdings are small and they are living in the area primarily to enjoy its aesthetic, social and cultural amenity. Most of them are comparatively new to the district and have a different perspective of the environment than the farmers. These differences in attitudes could lead to human-human conflicts within the community if the two frames of reference were brought into contention over management strategies.

4. *Determine the relationship, if any, between local landholder attitudes and perceived deer damage in the Nariel Valley.*

Attitudes to deer were strongly correlated to perceived deer damage. Those landholders that experience damage due to deer were more likely to perceive deer negatively and support pest declaration, a reduction of their population, and lethal control techniques.

Damage experienced as a result of deer significantly influenced people's attitudes. What is perceived to be damage varies considerably from one person to another. Some landholders who had damage to fruit trees as a result of deer rubbing or grazing of their vegetable garden did not perceive it as negative overall, as the impacts were outweighed by the aesthetic benefit of seeing deer in the garden. Most people reported only being aware of deer in the valley during the last five to ten years, so deer were often perceived as a novelty. This is likely to change with an increase in the deer population and subsequent increase in the level of damage to lifestyle property owners. This expected change in attitude response, as a consequence of growth in the deer population, will probably result in a greater willingness for control and management of the deer. This demonstrates the importance of continuing to monitor community attitudes periodically as it will allow management strategies to be adjusted accordingly.

5. *Identify the options for managing deer in the valley and the likely attitude of the local stakeholders to their application.*

The options for management that people found most acceptable were influenced by their attitudes to deer. Where people did not feel they were being negatively impacted by the animals, they were less tolerant of extreme methods. Currently the techniques most favoured by the community for control of deer are game meat harvesting and recreational hunting. Of the options proposed, trapping and poisoning were the least favoured.

While recreational hunting was identified as one of the preferred options for deer control, residents in the valley were concerned about the risks associated with it, including diminished social amenity, safety and the intrusive nature of hunting.

There is no evidence that recreational hunting is having a significant effect on deer populations. Anecdotal evidence suggests that deer populations are continuing to grow and

landholders report increasing damage by deer. Effective management of deer populations will require a coordinated strategic approach. For this to be acceptable, there will need to be a process of education and stakeholder engagement to effectively communicate why an alternative course of action is required to manage the deer population.

It must be understood that many landholders have independent attitudes and do not like what they see as government intrusion in their business. As with all management strategies which involve public and private land, there is a need to build trust, and if possible, a sense of mutual engagement and obligation. Otherwise there is a risk that the deer will be seen to be the public landholders' responsibility and problem. There is precedence with this with other feral species problems where the National Park is seen as the reservoir of the population of pest animals. Landholder engagement can give managers a valuable source of intelligence regarding deer populations and activities, and offer a potentially very useful component in holistic management.

Conclusion

This pilot study was based on a combination of qualitative and quantitative data which allowed a more complete picture of the complex wild deer management situation to be obtained. This study which has included ecological and social factors has achieved two things; first it has provided a clearer picture of the deer activity in the Nariel Valley; and second it has given a snapshot of the range of perceptions and attitudes that landholders have to the deer.

This type of study cannot provide definitive answers to such a complex management problem, because there are still gaps in our knowledge. In order to create an appropriate management strategy there needs to be an adaptive management approach that will allow adjustment to new circumstances including increases in knowledge, environmental change and changes in community attitudes. Any management strategy must be based on knowledge of the pest species, including its biology, fecundity, population dynamics, density, movement and the nature of the damage they are causing. This management needs to be coordinated with a clearly articulated outcome and use the most appropriate control techniques, and there must be a monitoring process to ensure that it is achieving the primary objectives.

A major limitation of this study is that it did not include external stakeholders such as hunters, which have the potential to form a very powerful political lobby. Their attitudes and political influence are likely to be key factors on how deer are managed in the Nariel Valley. Any management plan will need to consider the priorities, values and influence of this group.

This type of research integrating ecological and sociological research is fairly innovative but necessary to address the complexities of 'wicked' environmental problems. While the ecological information is essential to provide an evidence-basis for management strategy development, it is the human perspective that determines management priorities and appropriate methodologies. Considerable engagement will be needed with all relevant stakeholders to develop an acceptable, effective management approach.

In order to maintain an adaptive management model, further research is required to gain a deeper understanding of the complexity of the issues involved in the management of wild deer populations. This would enable the development of appropriate and effective management approaches.

In order to ensure ongoing conservation of Australia's diverse and complex ecosystems, a detailed understanding of the range of existing and emerging threats is required. Humans are a fundamental force shaping Australia's landscape. Any management program needs to consider these two interrelated dimensions in order to effectively implement appropriate conservation strategies to minimise damage. This is critical to maintaining these unique and precious environmental assets for generations to come.

Future Research

Areas in which additional research could be undertaken that would help enhance the limited understanding of ecological and social impacts of wild deer include:

Ecological

1. Investigate the distribution, home range, population trajectories and carrying capacity of wild deer in different habitats, including establishing plausible upper bounds of deer populations in the Nariel Valley.

2. Investigate factors such as aspect, distance from water, proximity to cleared land, altitude etc. which could influence habitat preferences of deer.

3. Assess the long-term impacts of deer on vegetation structure and diversity, and determine which species of vegetation deer preferentially browse.

4. Undertake a longitudinal spatial and temporal study of deer activity in order to better understand their behaviour and population dynamics.

5. Assess the effectiveness of recreational hunting and alternative population control techniques to manage deer.

Social

1. Undertake a full survey of public perceptions and set up a programme of on-going research to monitor changes in opinion.

2. Establish community attitudes to the presence of deer, including acceptable population densities amongst hunters, conservation groups, landholders and other stakeholders.

3. Identify what the impacts of recreational and illegal hunting are on surrounding landholders.

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Appendices

Appendix 1 Biology of deer species present in the Nariel Valley, Victoria.

Sambar Deer (*Cervus unicolor* Kerr 1792)

Sambar Deer (stag)

Sambar Deer (hind)

Sambar deer are a large deer species native to south-east Asia. Stags (male deer) weigh 200 – 250 kg and stand up to 130 cm at the shoulder. Mature hinds (female deer) weigh 130 – 150 kg and stand up to 115 cm at the shoulder (Bentley 1978; Bennett and Coulson 2008).

They are shy and mostly crepuscular to nocturnal. The habitat requirements of sambar are: dense forest in close proximity to water, gullies, forest edges and/or open clearings (Yamada et al 2003; Forsyth *et al.* 2009). Sambar are considered to be the 'dominant transplant' being the most successful of the deer species present in Australia (Bentley 1998; Moriarty 2004).

Sambar both graze and browse and can consume a very wide variety of plant material. They are reportedly able to consume virtually all native and non-native plant species which are available to them within the lowest 2 metre of the forest (Van Dyck 2008).

The stags are generally solitary, with hinds and offspring forming small groups of 3 - 4 individuals (Long 2003). However in areas of productive forage large numbers may congregate (Bennett 2008). Hinds become sexually reproductive in their second year and typically have one calf annually, after a gestation period of 240-270 days (Long 2003). Peak calving usually occurs between May and July in Australia (Bentley 1978; 1998).

Sambar stags produce and cast antlers annually from the age of 2 years (Bentley 1978; 1998). Sambar stags rub their antlers on trees to remove their velvet and to mark their territory (Bentley 1978; 1998). They are in hard antler for approximately 6 months of the year.

Red deer (*Cervus elaphus* Linnaeus 1758)

Red Deer (stag)

Red Deer (hind)

Red deer are a large species of deer native to Europe and Asia. Mature red deer stags weigh up to 220 kilograms and stand up to 122 cm at the shoulder. Hinds are smaller, weighing up to 100 kg and stand up to 90 cm at the shoulder (Jesser 2005).

They are mostly crepuscular and highly versatile and can adapt to a range of environments (Long 2003). They are a browsing animal which will also graze on pasture so they are thought to prefer habitat of open grassy patches in forests (Jesser 2005).

They are a herd animal, living in discrete groups of approximately 9 - 40 individuals. The sexes remain apart for most of the year however hinds and young form matriarchal herds. The two groups come together during the breeding season for rut. Rut commences in March-April and lasts for approximately 6 – 12 weeks. Stags become very aggressive during rut, fighting for females and forming harems of up to 50 hinds (Van Dyck 2008). Hinds give birth to a single calf, after a gestation period of 210-262 days.

Like sambar and fallow, they rub their antlers on trees as they move from velvet to horn. This is both a territorial marker and a means of strengthening the horn in preparation for rut.

Fallow deer (*Cervus dama* Linnaeus 1758)

Fallow Deer (buck)

Fallow Deer (hind)

Fallow are a medium sized deer native to Europe. Bucks (name for a stag) weigh up to 90 kg and stand up to 90 cm at the shoulder. Hinds weigh up to 42 kg and stand up to 76 cm at the shoulder (Jesser 2005).

Fallow, unlike the other deer species, are mostly diurnal and crepuscular, with peak activity at dawn and dusk (Long 2003). Fallow are less suited to hot conditions compared with other introduced deer species, preferring temperate climates. Young fawns have low tolerance to extreme heat and require access to cool, shaded areas. Forested country in close proximity to pasture and cover is thought to be their favoured habitat in Australia (Jesser 2005).

They are a herd deer, with group sizes and composition varying between seasons (Van Dyck 2008). The breeding season in Australia generally begins in April, lasting on average 6 – 8 weeks. Does give birth to a single fawn (rarely two) after a gestation period of roughly 230 days (Van Dyck 2008).

Bucks grow antlers annually in mid-February which are cast in October. Antlers are used for territorial behaviour such as marking and thrashing vegetation and for intimidation of rival males (Van Dyck 2008).

Appendix 2 Description of the four main EVCs in the Nariel Valley.

The following outlines the main characteristics of each EVC, as defined by the Victorian Government Department of Sustainability and Environment (DSE, 2007):

Herb-rich Foothill Forest

A medium to tall open forest to 30 m tall with a small tree layer over a sparse to dense shrub layer. Occurs on relatively fertile, moderately well-drained soils on an extremely wide range of geological types and in areas of moderate to high rainfall. Occupies easterly and southerly aspects mainly on lower slopes and in gullies. The understory contains a high cover and diversity of herbs and grasses in the ground layer, which characterises this EVC.

Heathy Dry Forest

Open eucalypt forest to 20 m tall. Grows on shallow, rocky skeletal soils on a variety of geologies and on a range of landforms from gently undulating hills to exposed aspects on ridge tops and steep slopes at a range of elevations. The understory is dominated by a low, sparse to dense layer of ericoid-leaved shrubs including heaths and peas. Graminoids and grasses are frequently present in the ground layer, but do not provide much cover.

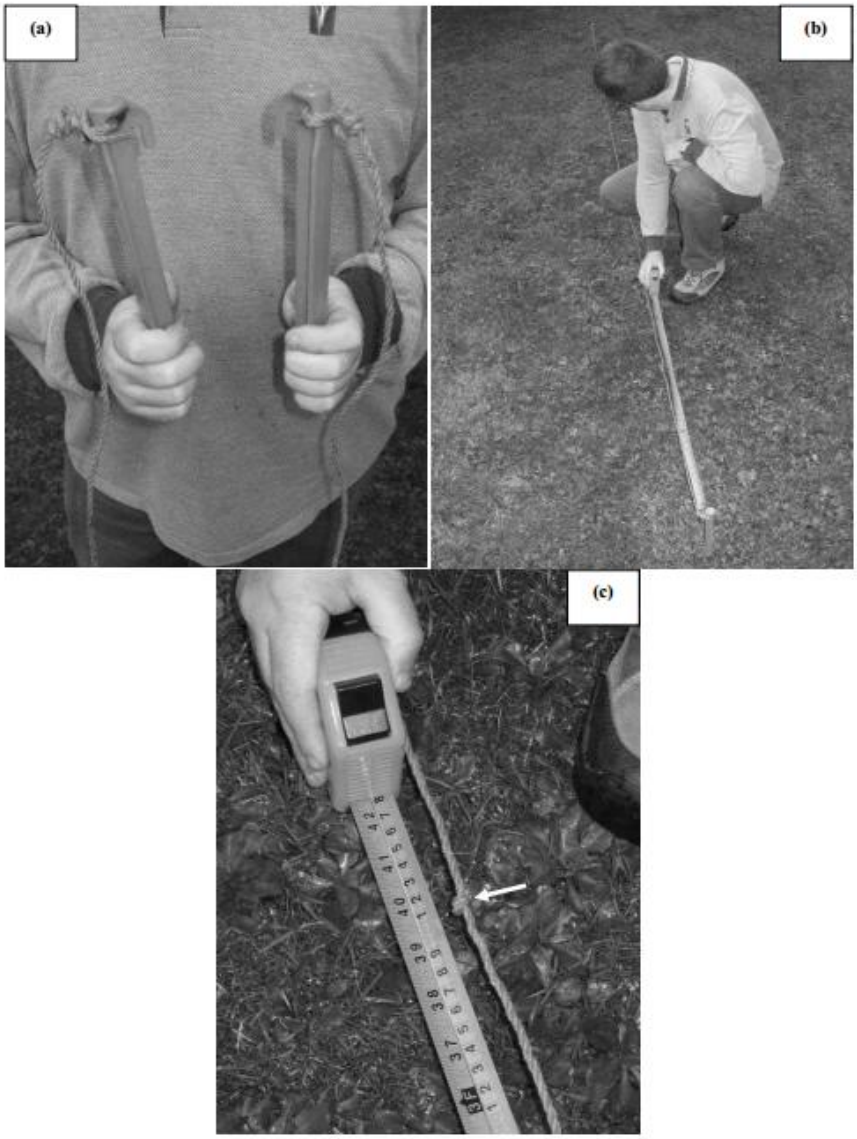
Grassy Dry Forest

Occurs on a variety of gradients and altitudes and on a range of geologies. The overstory is dominated by a low to medium height forest of eucalypts to 20 m tall, sometimes resembling an open woodland with a secondary, smaller tree layer including a number of *Acacia* species. The understory usually consists of a sparse shrub layer of medium height. Grassy Dry Forest is characterised by a ground layer dominated by a high diversity of drought-tolerant grasses and herbs, often including a suite of fern species.

Shrubby Dry Forest

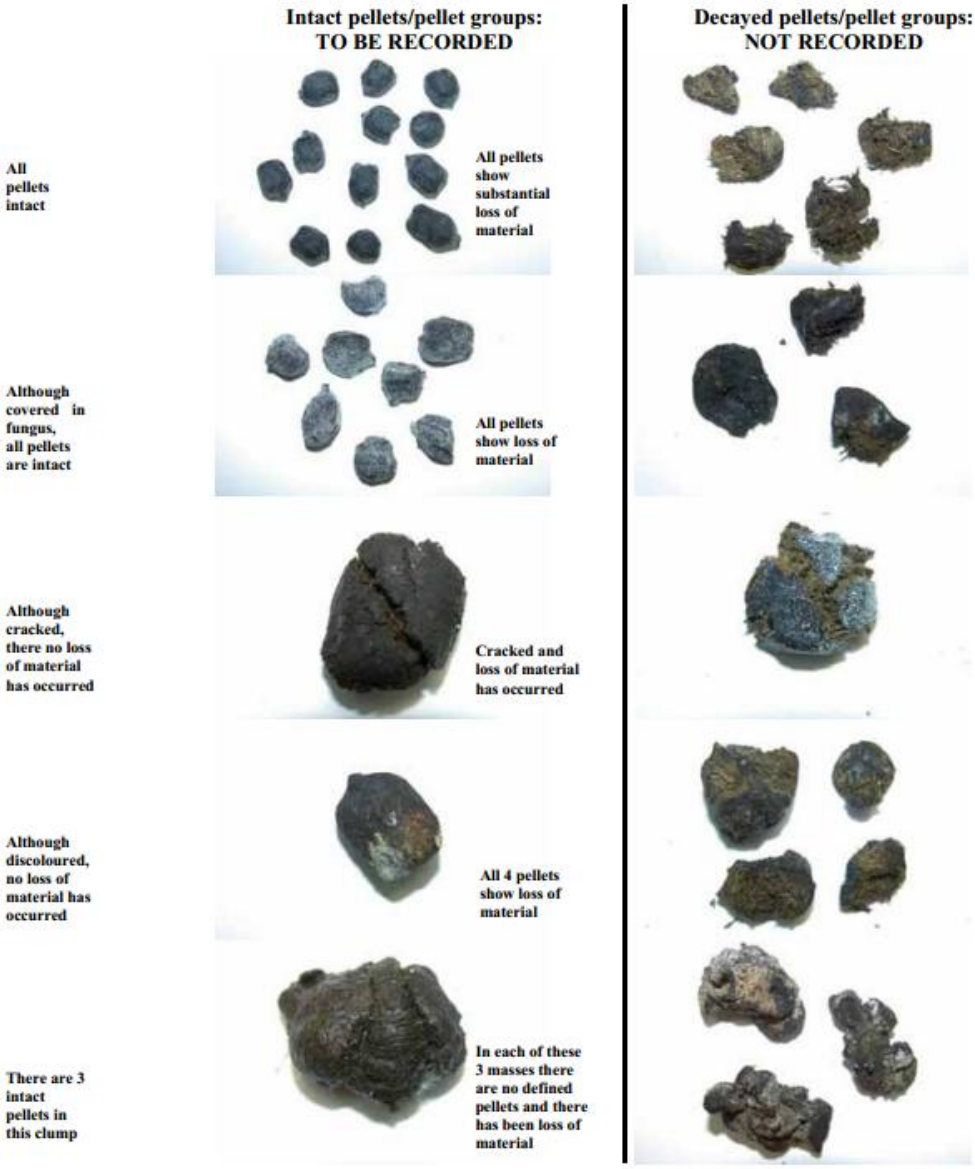
Occurs on a range of geologies on exposed aspects such as ridge-lines and medium to steep upper slopes, often in high rainfall areas and on shallow infertile soils. The overstory is an open forest to 25 m tall characterised by the diversity and variability of the eucalypts. The understory often lacks a secondary tree layer but contains a well-developed medium to low shrub layer. The ground layer is often very sparse with tussock-forming graminoids being the dominant life form.

Appendix 3 The running line used in faecal pellet surveys. Source: Forsyth (2005).



Appendix 4 The definition of intact pellets as defined by Forsyth (2005).

An intact pellet is defined as having no recognisable loss of material, regardless of whether the pellet is cracked, partly broken or deformed (e.g., by trampling). The presence of moss or fungus does not affect whether a pellet is considered intact or not.



Appendix 5 Questionnaire

By completing this survey you offer your informed consent to your non-identifiable responses being used for the purposes of completion of a research thesis and publication of the results.

---

1. How big is the land you own/manage?

.....

2. What is the main use of your property?

Beef ☐
Dairy ☐
Crops ☐
Lifestyle ☐
Residential ☐
Other ☐ Please specify.....

3. How long have you owned or occupied property in the Nariel Valley for?

Less than 1 year ☐
1-5 years ☐
5-10 years ☐
10-15 years ☐
More than 15 years ☐

4. Do you own or manage/lease your property in the Nariel Valley?

Own ☐
Manage/Lease ☐

5. Are wild deer present on your property?

Yes, always ☐
Yes, sometimes ☐
No, never ☐
Unsure ☐

6. For how many years have you been aware of the presence of deer on your property or in the valley?

0 – 2 ☐
2 – 5 ☐
5 – 10 ☐
10 – 30 ☐
30 + ☐

7. Do deer cause negative impacts on your property? Please circle

Yes / No

If Yes: what types of impacts?.....

.....

8. Do you control deer on your property? Please circle

Yes / No

If Yes: what methods do you use to control deer? .....

.....

9. What population level would you like to see for deer in the area?

Present population level ☐
Greatly increased ☐
Slightly or moderately increased ☐
Slightly or moderately reduced ☐
Complete removal ☐

10. If deer populations needed to be controlled, what methods would be acceptable to you?

Game meat harvesting ☐
Poisoning ☐
Recreational hunting ☐
Trapping ☐
Fertility control ☐
No management ☐

11. Do you participate in recreational hunting of deer? Please circle

Yes / No

If Yes: How often?.....

If No: why not? .....

12. Do you think deer should be declared a pest?

Yes, for declaration ☐

No, against declaration ☐

Why? .....

13. Attitudes to deer (please tick the box which most accurately describes your opinion)

Statement	Strongly disagree	Disagree	Neither	Agree	Strongly agree
Wild deer cause environmental damage on my property					
Wild deer are an agricultural pest on my property					
Wild deer significantly compete with livestock on my property					
Wild deer are a management problem on my property					
I enjoy having deer on my property					
Wild deer provide a useful source of income to my business					
Wild deer are an asset to my property					
I view wild deer as similar to native species					
I view wild deer as similar to feral pests					
I view deer as a game species					
In general, I do not like having deer on my property					
It is important to maintain wild deer populations for future generations to enjoy.					

14. How would you rank the significance of these species as a pest in the Nariel Valley? Please rank 1 – 10 where 1 is the most significant and 10 is the least.

Species	Rank (1- 10)
Feral cats	
Rabbits	
Wild dogs/dingoes	
Foxes	
Mice	
Rats	
Wild deer	
Wombats	
Kangaroos	
Wallabies	

Thank you for completing this survey. Your participation is greatly appreciated.

Appendix 6 Participation consent form

I, ... [PRINT NAME], agree to take part in this research study.

In giving my consent I state that:

- ✓ I understand the purpose of the study, what I will be asked to do, and any risks/benefits involved.
- ✓ I have read the Participant Information Statement and have been able to discuss my involvement in the study with the researchers if I wished to do so.
- ✓ The researchers have answered any questions that I had about the study and I am satisfied with the answers.
- ✓ I understand that being in this study is completely voluntary and I do not have to take part. My decision whether to be in the study will not affect my relationship with the researchers or anyone else at the University of Canberra now or in the future.
- ✓ I understand that I can withdraw from the study at any time.
- ✓ I understand that personal information about me that is collected over the course of this project will be stored securely and will only be used for purposes that I have agreed to.
- ✓ I understand that the results of this study may be published, and that publications will not contain my name or any identifiable information about me.

Would you like to receive feedback about the overall results of this study?

If **YES**, please indicate your preferred form of feedback and address:

☐ Postal: _____

_____

☐ Email: _____

.....

Signature

.....

Date

Appendix 7 Participation Information sheet

Project Title: *Wild Deer in the Nariel Valley: A baseline study examining the social perceptions and attitudes of rural landholders towards wild deer abundance and management in the Nariel Valley, Victoria.*

Researcher

Name: Francesca Bowman
Phone: 0424 599 172
Email: Francesca.Bowman@canberra.edu.au

Supervisor

Name: Jasmyn Lynch
Phone: (02) 6201 2517
Email: Jasmyn.Lynch@canberra.edu.au

Project Aim: The aims of this research are twofold: the study will explore the ecological and sociological aspects of deer management in the Nariel Valley, Victoria. First, the study will establish baseline data on wild deer abundance and impacts in the Valley to identify their influence on the local environment. Second, the study will examine landholder's attitudes toward wild deer to determine some of the factors that influence people's attitudes, and the implications for management.

Benefits of the Project: The study represents an opportunity to gauge the need for a management response, and to identify management strategies that are acceptable to the community. Further, the data will constitute a baseline for monitoring deer abundance and impacts, thereby providing a foundational reference for future research.

General Outline of the Project: There are estimated to be over 200,000 wild deer in Australia, with numbers expected to increase significantly as they expand their range to occupy suitable habitats. The perceptions of deer in this country are diverse and often divergent, as are the community views regarding the appropriate direction for deer management. As people are a major presence in and influence on landscapes, any successful attempt at managing wild deer will require the cooperation of numerous stakeholders and consideration of the diversity of views and opinions. It is therefore of paramount importance to integrate the human dimension with the ecological science, in order to promote best practice management of wild deer populations.

Participant Involvement: Individuals who agree to participate in the research will be asked to:

1) Fill in a short survey on their experiences with wild deer.
   And/or
2) Participate in a short (20 minute) interview with the researcher about their experience with deer on their land and in the surrounding environment.

Participation in the research is completely voluntary and individuals may decline to take part or withdraw at any time without providing an explanation, or refuse to answer a question. Individuals may choose to participate in just one or both of the research components. While I,

Francesca Bowman, value and encourage participation, I respect the right of individuals to choose not to participate in research.

Confidentiality: Only the researcher and the researcher's supervisor will have access to the individual information provided by clients. Privacy and confidentiality will be assured at all times. The research outcomes will be provided in an Honours Thesis to the University of Canberra and may be presented at conferences and written up for publication. However, in all these reports, the privacy and confidentiality of individuals will be protected.

Anonymity and Data Storage: Please be assured that all reports of the research will contain no information that can identify any individual and all information will be kept in the strictest confidence. The information collected will be stored securely on a password protected computer throughout the project and then stored at the University of Canberra for the required five year period after which it will be destroyed according to university protocols.

Ethics Committee Clearance: The project has been approved by the Human Research Ethics Committee of the University of Canberra.

Queries and Concerns: Queries or concerns regarding the research can be directed to the researcher and/or supervisor. Their contact details are at the top of this form. You can also contact the University of Canberra's Human Research Ethics Officer, Mr Hendryk Flaegel, via phone (02) 6201 5220 or email hendryk.flaegel@canberra.edu.au.

Appendix 8 Human Ethics Approval

UNIVERSITY OF CANBERRA
AUSTRALIA'S CAPITAL UNIVERSITY

19 May 2014

APPROVED - Project number 14-79

Ms Francesca Bowman
Faculty of Education, Science, Technology & Maths
University of Canberra
Canberra ACT 2601

Dear Francesca,

The Human Research Ethics Committee has considered your application to conduct research with human subjects for the project titled **The ecological impacts and the social perception of wild deer in the Nariel Valley, Victoria; baseline data to inform future management.**

Approval is granted until 19 November 2014.

The following general conditions apply to your approval.

These requirements are determined by University policy and the ***National Statement on Ethical Conduct in Human Research*** (National Health and Medical Research Council, 2007).

Monitoring:	You must, in conjunction with your supervisor, assist the Committee to monitor the conduct of approved research by completing and promptly returning project review forms, which will be sent to you at the end of your project and, in the case of extended research, at least annually during the approval period.
Discontinuation of research:	You must, in conjunction with your supervisor, inform the Committee, giving reasons, if the research is not conducted or is discontinued before the expected date of completion.
Extension of approval:	If your project will not be complete by the expiry date stated above, you must apply in writing for extension of approval. Application should be made before current approval expires; should specify a new completion date; should include reasons for your request.
Retention and storage of data:	University policy states that all research data must be stored securely, on University premises, for a minimum of five years. You must ensure that all records are transferred to the University when the project is complete.
Contact details and notification of changes:	All email contact should use the UC email address. You should advise the Committee of any change of address during or soon after the approval period including, if appropriate, email address(es).

Yours sincerely
Human Research Ethics Committee

Hendryk Flaegel
Research Ethics & Compliance Officer
Research Services Office
T (02) 6201 5220 F (02) 6201 5466
E hendryk.flaegel@canberra.edu.au

www.canberra.edu.au
Postal Address:
University of Canberra ACT 2601 Australia
Location:
University Drive Bruce ACT
Australian Government Higher Education Registered Provider Number (CRICOS): 00212K