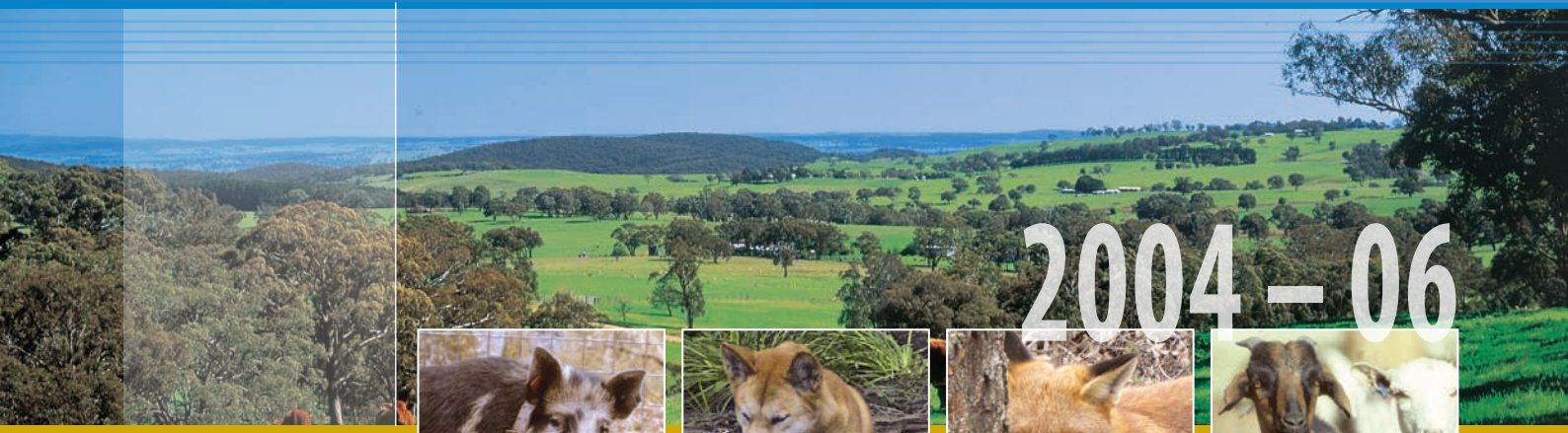
NSW DPI

Pest Animal Survey



2004 – 06




A review of the distribution, impacts and control of invasive animals throughout NSW and the ACT.

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Abbreviations and acronyms

Arcview	Arcview GIS software (licensed to ESRI Australia)
CSSP	Phosphorus poison
DEC	Department of Environment and Conservation
DWLBC	Department of Water Land and Biodiversity Conservation
DPI	Department of Primary Industries, NSW Government
EPBC	Environment Protection and Biodiversity Conservation Act
GIS	Geographic Information System
QLD DNRW	Queensland Department of Natural Resources and Water
RCD	Rabbit-Calicivirus Disease
RLPB	Rural Lands Protection Board
1080	Sodium monofluoroacetate

EXECUTIVE SUMMARY

The environmental, economic, and social impacts of invasive pest animals in Australia cost in-excess of $700 million annually (Mcleod 2004). Invasive pest animals inhabit all regions of the State, and are well-recognised as causing significant losses to primary production, damaging environmental assets, threatening native species and communities, and impacting on social values. Effective management of pests and their adverse impacts often requires a coordinated approach between government, regional organisations and landholders. All groups have a shared responsibility to ensure the sustainable management of natural resources and to address the damage caused by pest animals throughout NSW. Information contained in this report represents the findings of one approach in monitoring and reporting aimed at presenting information on the distribution, abundance, impacts and control of pest species throughout NSW. The species addressed in this survey are feral pigs, feral goats, wild deer, foxes, rabbits, wild dogs and dingoes, feral cats, European starlings, European carp and cane toads.

In the years preceding this survey, widespread drought was thought to have caused significant reductions in the extent and associated impacts of many pest species. While localised reductions in abundance, accompanied by reductions in impacts, were observed during this period, broad-scale reductions in animal populations were not apparent. Most species were perceived to have endured the drought conditions throughout much of their range. Some species even marginally increased their range. Reluctance or an inability of many landholders to undertake control activities may have lead to some pest populations increasing during this period. Activities such as illegal transportation and release of some species were also implicated as contributing to these trends.

Of particular concern is that the range of wild deer (comprising 6 species in NSW) has increased considerably in recent years. Wild deer have been reported from an additional 30 separate locations throughout the State (equating to over 8000km^2). This trend raises a concern that without development and implementation of cost-effective control strategies; adequate resourcing for control; and on-going surveillance for emergent populations. Consequently, wild deer may spread further throughout the State and may become prohibitively costly to control.

Increases in pest abundance do not always directly translate to increases in pest impacts. While there were anecdotal accounts of reductions in pest impacts, the types of impacts observed throughout NSW were very similar to those reported during 2002. This report presents changes in the perceived impacts of pest animals between 2002 and 2004/05 as a benchmark for assessing future trends in impacts throughout the State. Measuring and reporting spatial and temporal trends in the impacts of pest animals, particularly in response to control or changes in control practices, is vital for the development of cost-effective management programs. This survey also indicates that the impacts of most species (and control measures implemented to counteract those impacts) were highly varied between Divisions of the State. These findings support a need for region-specific management plans and control strategies, and an equal need for monitoring programs to complement those plans.

There are a wide variety of control techniques used to counter-act the impacts of pest animals throughout NSW. Commonly used techniques include, trapping, aerial shooting,

poison baiting and the use of livestock guarding animals. For some species, commercial harvesting also remains an important control technique, and can be used to rapidly reduce populations and simultaneously provide an income. Recreational hunting is also widely used for several pest species, however, careful planning and regulation are required to ensure activities are targeted to maximise their effectiveness at reducing the impacts of pest animals. In short, mechanical control techniques were most commonly used for all species, followed by chemical control, and biological control techniques.

The development of management plans and monitoring strategies is critical in the process of controlling pest animals and their impacts. There are a wide variety of tools and techniques available for pest control, and planning an integrated approach (using a range of techniques) is considered the best way to reduce the long-term impacts of pest animals. Furthermore, adopting best-practice management principles through problem definition, identifying the pest species of concern and their geographic range, developing and implementing collaborative management strategies, and monitoring outcomes are also crucial steps in pest animal management planning (Braysher and Saunders 2007). In recent years, management authorities and land managers have been encouraged to adopt best-practice principles and by develop management plans through PESTPLAN (Braysher and Saunders 2003) which provides a valuable tool to assist land managers develop regional management plans and strategies tailored specifically to their regional circumstances.

Monitoring the success of management strategies using appropriate methods is essential to maximise cost-effectiveness. This can be achieved by carefully assessing the extent and impacts of pest animals in response to control. Monitoring is also important for identifying priorities for management planning and resourcing; evaluating previous management activities; and raising awareness and education of issues, problems and opportunities. Relief from the long-term impacts of pests can only be achieved if these principles are applied. Commonly used techniques for monitoring pest populations include spotlight counts, aerial surveys, counts of animal sign, trapping techniques and various measurements of animal damage (Mitchell and Balogh 2007).

It is important that meaningful information on pest animals is made available to stakeholders during the planning of control programs. This report provides state-wide representation of pest animal extent, impacts and control to provide a platform for regional pest animal planning, and a benchmark for ongoing monitoring and reporting activities.

RECOMMENDATIONS

Several species continue to expand their range and associated impacts, despite adverse climatic conditions, intensified control programs, and increased awareness of pest management issues. As a result, there is a genuine need for regular monitoring and reporting of existing pest populations, and comparison of information over time to assess the effectiveness of current policy and management planning. There are also many other species that have the potential to become pests in NSW. Emerging species, such as wild deer, also present a significant problem if strategies for their containment, control, or eradication are not sufficiently applied. Surveillance and the development of control strategies are needed to address emerging pest species in NSW. There is also a need to develop suitable policies to support control activities (along with existing legislation) to reflect the current status of pest species throughout the State.

Arising from this report is a number of recommendations regarding monitoring of pest animals to support the NSW Invasive Species Plan.

For regional management planning, we recommend:

- regional management plans are developed within a State planning framework; and
- distribution and abundance information reported herein is used to support the PESTPLAN prioritisation process throughout regions of NSW and to promote best practice and strategic planning.

For state-level management planning, we recommend:

- continued monitoring of the distribution and abundance of established species through state-wide surveys (at suitable intervals) given persistence of many species to drought conditions throughout the State (and their potential recovery), and the risks pests may pose to exotic disease transmission and maintenance (such as foot-and-mouth disease);
- repeating this state-wide survey to update and improve baseline data to support policy development, evaluate management effectiveness, improve control, and respond to emerging issues;
- that the distribution and abundance of emerging species (such as wild deer) is used as the basis for management recommendations, and that increases are required in surveillance of emerging species such as those highlighted in Bomford 2003;
- incorporation of detailed local or regional scale data wherever available to improve state-wide information, and field verification of information to support informed decision-making regarding prioritising, planning, and resourcing of management activities;
- the development, implementation and adequate resourcing of an agreed impact monitoring framework to complement current population abundance information, to improve impact-based management decisions;
- adoption of an agreed and consistent monitoring protocol within NSW (local and regional levels), that is consistent with other states/territories to address monitoring and reporting at all levels, and to support comparisons of management across jurisdictions; and

- alignment of state monitoring and reporting activities with national activities to ensure an enduring process of monitoring against natural resource management targets.

1 INTRODUCTION

1.1 Background

The total costs of pest animals in Australia have been estimated at over $700 million annually (McLeod 2004). These costs are considered conservative due to lack of information about the cumulative impacts of pest species such as land degradation. In NSW, there are many species that are considered pests because of their adverse affects on our environmental, agricultural and social values. Pest animals include introduced species (such as feral goats) and over abundant native species (such as kangaroos). The suitability and variety of habitats, modified landscapes, lack of natural predators, and absence of zoonotic diseases are some of the reasons why many introduced species have become well-established in this country. The management of pest animals is rarely simple, as some species may cause significant impacts but are simultaneously valued as a resource or are protected for their conservation value. As a result, managing these competing priorities is a challenge currently faced by land managers throughout Australia.

In the agricultural regions of NSW, the primary pest species of concern are feral pigs, feral goats, wild deer, foxes, rabbits and wild dogs/dingoes (West and Saunders 2003). Less than 0.3% of NSW can claim freedom from these species. Other pests of concern include feral cats, European starlings, introduced carp, and cane toads. The management of these species relies on having detailed information about their distribution and abundance, biology, breeding behaviour, movement, and the suitability of various control and monitoring techniques to allow populations to be adequately managed. It is equally important to understand or monitor the impacts of pest animals particularly in response to control. However, impact monitoring and reporting is generally difficult without rigorous field data collection and sufficient resources.

While pest animals have many direct impacts, there are also many associated, and often substantial, costs incurred by land managers, such as the ongoing costs of control. As a result, it is critical to design, coordinate and implement control programs with care to reduce the costs of control while ensuring management objectives are achieved. Identifying and targeting areas where pest animals are most problematic, and/or focusing on areas where the affects of control are likely to generate the greatest rewards, are ways to reduce the overall long-term costs of control and sustain maximum benefits to the environment and agricultural production. To evaluate control programs, meaningful information is required on the effects of control interventions. This report presents the outcomes of a state-wide survey using agreed monitoring techniques to collect regional information on pest animals and to address many of these on-going management requirements.

In the years preceding this survey, widespread drought conditions was reported to have altered the distribution and abundance of many pest species, and the way they were managed. This report identifies changes in the pest animal populations and presents recommendations for pest species management.

1.2 Importance for pest animal planning and disease preparedness

The development of effective pest animal plans requires the adoption of best-practice management principles that involves defining the scope of a pest animal problem, the species of concern, their geographic range, appropriate management strategies, and the monitoring of control outcomes (Braysher and Saunders 2007). Management authorities and land managers are currently being urged to adopt best-practice guidelines through assigning pest animal priorities, and by developing management plans through PESTPLAN (Braysher and Saunders 2003). The PESTPLAN framework aims to improve pest animal management and to achieve tangible management outcomes. The survey and mapping of pest animal populations throughout NSW is complementary to this process, enabling land managers to monitor progress, target pest animal populations and measure responses to management practices.

The outcomes of previous state-wide mapping surveys have been used to develop cooperative management programs, disseminate operational funding, prioritise regional pest control activities, and in monitoring the performance of large control programs. This current report builds on previous survey information to deliver improved mapping of pest animals to address these on-going needs, and to identify emerging populations of pest species throughout NSW.

The potential for large-scale exotic disease emergencies involving wild animals remains a concern for wildlife health authorities throughout Australia. The exact roles that wild animals may play in an exotic disease outbreak are uncertain. However, many species (e.g. feral pigs) may potentially act as reservoirs in the maintenance and transmission of exotic disease. Pre-emptive control of wildlife populations in response to perceived exotic disease risks is impractical (Saunders 2001). According to AUSVETPLAN, upon detection of a notifiable disease in Australia, authorities would be required to promptly collate information on the distribution and abundance of susceptible animal hosts and to develop and coordinate an appropriate disease response plan. Previous NSW state-wide mapping surveys address this requirement at a regional and state-wide scale, and this report value-adds to these previous surveys by updating disease-host abundance information.

1.3 Previous surveys and trends in abundance

There have been several state-wide surveys of major pest animals in NSW: 1979, 1985, 1996 and 2002. These surveys have been used to highlight variation in pest animal populations and have produced a generalised assessment of the geographic range of pest species. Foxes and rabbits have been found to be widespread throughout most of the state, while feral pigs and feral goats were mainly concentrated throughout the tablelands and far-western NSW. Wild deer and wild dogs were localised along the coastal and tablelands divisions, but abundant within their range. Populations of wild deer also appeared to be increasing. This report presents additional information to identify trends in the abundance of these species throughout NSW.

1.4 Capturing knowledge through consultation

The most robust methods for measuring the abundance of pest animals involve direct counting of animals using rigorous field sampling techniques, such as spotlight counts and aerial surveys. Although field sampling provides informative and detailed data about the distribution and abundance of wild animal populations, in most cases it is prohibitively expensive and labour intensive, particularly if required for large areas. As a result, alternative (or supplementary) strategies have been developed for broad-scale assessment of wild animal populations, to address information needs and facilitate appropriate planning activities.

This report describes generalised trends in the distribution and abundance of pest animals throughout NSW and the ACT using an innovative and reliable knowledge-based technique. It captures two types of information: information contained within formalised datasets and records wherever available and referred to by land managers, and perception-based information from land managers based on their experiences and observations. This method has been applied in previous NSW surveys (e.g. Hone and Waithman 1979; Croft unpublished 1979; Bryant unpublished 1985; West and Saunders 2003), in Queensland through the Annual Pest Distribution Survey (Qld. DNRW), in Western Australia (Woolnough *et al*. 2005), and very recently in South Australia (Williams, DWLBC, pers. comm. 2006) to report state-wide trends in animal populations. Landholder or land manager knowledge, also referred to as institutional knowledge represents an under-utilised resource for addressing broad-scale management goals (Woolnough *et al*. 2004).

1.5 Climate history and control initiatives

During the previous 5 years, much of eastern Australia has experienced widespread drought conditions. In mid-2004, drought affected areas accounted for approximately 87% of the NSW (source: NSW DPI). These conditions impacted heavily on agricultural enterprises and many rural communities. In response to widespread drought, both the Federal and NSW Governments committed drought relief funds of approximately $2million to increase the control of feral pigs and foxes in drought afflicted regions (mainly the Western Division). These funds were provided to purchase essential resources to increase control efforts using aerial and ground-based control techniques; to reduce the immediate impacts of these pests on livestock producers; and to take tactical advantage of the drought and reduced and contracted densities of these pests, particularly around permanent water sources. Anecdotal reports indicated that there were substantial declines in these pest animals and their impacts within the areas where control had been conducted. Establishing the scale of reductions was not considered a priority at the time, but was apparent throughout this survey.

2 PROJECT INFORMATION

2.1 Project Title

Pest animal survey: A review of the distribution, impacts and control of invasive animals throughout NSW and the ACT, 2004-2006.

2.2 Collaborating organisations

Rural Lands Protection Boards, NSW Department of Environment and Conservation (National Parks and Wildlife Service), Environment ACT, Game Council of NSW, and Birds Australia.

2.3 Project Aims

Below average rainfall throughout much of NSW in recent years has resulted in the decline in landholder resources available for controlling pest animals. It is important to identify how pest animal populations respond to periods of dry, and to concerted control initiatives which may take advantage of these conditions. It is also important to maintain current information on the distribution and abundance of invasive animals to plan and evaluate specific control activities, and for the allocation of management resources to priority areas. Previous surveys have revealed considerable expansions in the range of some species in NSW, such as wild deer which raises concern that there are emerging pest species throughout the State.

The key aims of this project were to:

1. Identify and highlight any changes in the distribution, abundance, control and impacts of invasive pest animals throughout NSW and the ACT since the previous survey in 2002;
2. Update generalised distribution and abundance maps of invasive pest animals throughout NSW to provide management agencies with a reliable tool to prioritise control programs; and
3. Survey and report on the distribution and abundance of additional pest species of significance in NSW.

2.4 Acknowledgments

We would like to acknowledge the support of the following organisations and individuals for assisting with the collection, collation and reporting of information for this review: 86 Rangers from the Rural Lands Protection Boards; 39 Pest Management Officers and operational staff from NSW Department of Environment and Conservation (National Parks and Wildlife Service); Paul Meek and Robert Madden (State Forests of NSW); Bill Woodruff and Graham Blinksell (Environment ACT); and Brian Boyle (Game Council of NSW). Dean Gilligan (NSW DPI Fisheries) contributed significant information, data and expert knowledge of NSW rivers to assist in European carp mapping. Birds Australia kindly provided detailed records of Starling sightings; and NSW National Parks and Wildlife Service and Arthur White (Frog Rescue Service) provided advice on established cane toad populations throughout NSW. Jo McKiernan and Jessica Gibson (NSW DPI) assisted with mapping, survey coordination and data delivery. This project was funded through NSW Department of Primary Industries and the Invasive Animals CRC.

3 PROJECT DESCRIPTION

The purpose of this report is to provide a synopsis of the distribution, abundance, control and impacts of the major invasive pest animals throughout NSW and the ACT during 2004-06. Results should be considered in combination with the findings of a comparable survey conducted during 2002 (West and Saunders 2003) to elucidate trends in the management of pest animals. This report also provides baseline information from multiple land management agencies which can be used as a guide to prioritising the control and long-term management of invasive animals and their impacts.

3.1 Survey species

There are many established pest animals in NSW and Australia, and many other emerging pests that have potential to cause significant impacts to the environment, economy (particularly primary production) and society. This survey focussed on species of significance in terms of 'triple bottom line' impacts in NSW, and has included both established and emerging pests. The key species that were selected for this survey were: feral pigs (*Sus scrofa*), feral goats (*Capra hircus*), wild deer (consisting of 6 species), foxes (*Vulpes vulpes*), rabbits (*Oryctolagus cuniculus*), wild dogs/dingoes (*Canis lupus familiaris*, *Canis lupus dingo*, and hybrids), feral cats (*Felis catus*), cane toads (*Bufo marinus*), European carp (*Cyprinus carpio*) and European Starlings (*Sturnus vulgaris*).

Many of these pests pose a risk for endemic and exotic disease transmission and some have also been listed as key threatening processes in NSW by the NSW Scientific Committee under the Threatened Species Conservation Act 1995 at the time or report production (Table 1).

Table 1. Listed Key Threatening Processes in NSW under the Threatened Species Conservation Act (1995) (source: NSW Department of Environment and Conservation)

Species	**Description of threatening process**
Feral Pigs	Predation, habitat degradation, competition and disease transmission
Feral Goats	Competition and habitat degradation
Deer	Herbivory and environmental degradation
Red Fox	Predation
European Rabbit	Competition and grazing
Feral Cat	Predation
Cane Toad	Predation and ingestion of toxin by predators

3.2 Methods

Detailed information about the distribution, abundance, impacts and control of pest animals throughout NSW and the ACT was captured through a two-part survey involving multiple land management agencies. Survey methods applied throughout the survey relied on consultation with Government and non-Government land management agencies in NSW.

3.2.1 Survey Group 1

Survey Group 1 involved a survey during 2004/05 consisting of a questionnaire on the impacts, control and management of invasive animal populations, and a complementary mapping exercise for reporting spatial trends in abundance. This Group contained feral pigs, feral goats, wild deer (consisting of 6 species), foxes, rabbits, and wild dogs /dingoes.

Questionnaire:
During 2004/05 a short mail-out questionnaire was distributed to Rural Lands Protection Boards to obtain information on the impacts, control and management of the above-mentioned pest species in the agricultural region of the state (see appendix 1). The questionnaire was designed to capture knowledge and experience of pest managers, gather information with relative simplicity, and re-address many issues and questions raised during the former survey of 2002. It also contained some outcomes from the 2002 survey to assist participants to make quick comparisons between years. In total, 48 questionnaires were received from experienced pest management staff within the Rural Lands Protection Board Districts, and responses were collated in a centralised database.

Mapping:
Pest animal managers and key representatives from Government and non-Government Agencies responsible for the control of pest animals throughout NSW and the ACT were also approached to assist in mapping the distribution and abundance of invasive animals across the state. The agencies involved in the mapping survey included the Rural Lands Protection Board Districts, NSW Department of Environment and Conservation (National Parks and Wildlife Service), NSW Department of Primary Industries (State Forests of NSW), Environment ACT, and Game Council of NSW.

The Survey was conducted during late 2004 and early 2005. Agencies received local-scale maps (via mail-out) depicting pest animal distribution and abundance (as collated during the 2002 survey), whereby changes in animal abundance, and any new populations of pest animals could be reported. It was considered highly beneficial to provide previous survey results to stream-line the reporting process with participants, particularly where there had been little or no change in pest populations. Where new populations had been detected in recent years, or where changes in populations had been determined, participants reported these changes on the maps provided.

The density/abundance of pest animals was estimated using consistent criteria with that used during previous surveys in NSW (Table 2; and West and Saunders 2003), and also successfully applied in Western Australia (Woolnough *et al*. 2004). The method was developed for field appraisal of pest animal relative abundance, and relies on effective communication of pest animal information from landholders to those involved in the assessment process. Seasonal variations in pest animal populations were not considered in the abundance estimates. It was important to ensure this survey replicated the methodology of the 2002 survey to facilitate comparability of outcomes. Where feasible, this survey involved the same agency staff involved in the 2002 survey. Maps were returned from the various agencies and the data was projected within ArcView GIS (ESRI v.3.2).

In total, 125 land managers assisted in the mapping of survey group 1 species, consisting of 86 operational staff (Rangers) from the 48 Rural Lands Protection Board (RLPB) Districts and, 39 pest management staff from NSW National Parks and Wildlife Service (NPWS), State Forests of NSW, Game Council of NSW, and Environment ACT.

Table 2. Density/abundance criteria for pest animals applied to survey group 1.

Density	Definition
High	*Many animals seen at any time and much sign of activity i.e. animals always observed, reliable sightings or otherwise evidence of high abundance. Best described as observing significant evidence of many animals on greater than 80% of occasions.*
Medium	*Some animals seen at almost any time and/or much active sign i.e. frequent but unreliable sightings of animals. Best described as observing significant evidence of some animals on 50-80% of occasions.*
Low	*Few or no sightings and/or little active sign i.e. rare sightings / evidence. Best described as observing very little evidence of animals on 1-50% of occasions.*
Absent	*No animals i.e. very unusual to see evidence of animals. Best described as seeing either no evidence or very little evidence of extremely low numbers of animals on less than 1% of occasions.*

3.2.2 Survey Group 2

Survey Group 2 involved a mapping exercise conducted during 2006 to capture spatial information to address emerging pest animal management priorities for four additional species, namely: feral cats; cane toads; European carp; and European starlings. Methods applied to capture and report information on these species varied from survey group 1 (described above). In total, mapping of survey group 2 species involved consultation with 64 operational staff and ecologists, as well as records from a number of spatial databases comprised of records from many field surveys and field observations. Fifty-eight RLPB Rangers contributed to the mapping of feral cats in NSW, and advice was provided by several NPWS staff for selected areas of the State. Starling data was obtained from the Birds Australia database (from records between 1998 and 2006) compiled from the surveys and research of many field biologists/naturalists. Carp data was supplied by Dean Gilligan (NSW DPI Research Scientist) from a database of records obtained during electro-fishing surveys conducted throughout the State by many Fisheries Officers and researchers. Cane toad data was provided by 6 operational staff and ecologists within NSW DEC and independent authorities.

Species specific information for group ‘2’ species was obtained as follows:

Feral Cats

Distribution and abundance information for feral cats was obtained through consultation with the Rural Lands Protection Boards (RLPB’s), with guidance from the NSW Department of Environment and Conservation (National Parks and Wildlife Service). Key representatives from these Agencies reporting information regarding the distribution and abundance of feral cats on maps of their respective jurisdiction; a process they were familiar with from involvement in previous surveys. Regional maps showing landscape features and land tenure were produced and distributed to key representatives from the RLPB Districts. Instructions were provided containing criteria for estimating feral cat

abundance using a 5x5 km grid array (see appendix 2). These criteria were modified slightly from other species (Table 2) to account for their elusive behaviour. Maps were returned and data collated within an ArcView GIS database. Representatives from the NSW Department of Environment and Conservation were consulted from various regions to provide additional information. There were no questionnaires used to gather information on feral cats, and this species was not mapped in the ACT.

Starlings

Information on the European starling was obtained from sighting records provided by Birds Australia (between 1998 and 2006) and reported as presence/absence, and an index for density (derived from the reporting rate) was calculated. Birds Australia retains the most accurate database currently available on wild birds throughout NSW (Birds Australia, Atlas of Australian Birds, 1998-2006). They have surveyed many areas of NSW using various field survey techniques, whereby the presence of species has been recorded. The Birds Australia data used for this project was obtained from 4 survey types (from which the outcomes were pooled):

- 2ha searches for 20 minutes;
- Area searches for at least 20 minutes within 500 metres of a central point;
- Area searches for at least 20 minutes within 5km of a central point; and
- Incidental observations.

For more information on field survey design and procedures see the Birds Australia Website: http://www.birdsaustralia.com.au/

Data obtained from Birds Australia, was interpolated using ArcView GIS to devise three separate map products:

1) Starling Presence/ Absence map – showing the areas (where surveys had been undertaken) where starlings had been observed in NSW.

2) Starling Density map – showing the abundance of starlings based on the reporting rate (number of observations/ number of independent surveys) for 10' areas (approximately 15km x 18km) of NSW. Abundance was ranked into three categories of high, medium and low based on a reporting rate of 1-33%, 34-66% and 67-100% respectively. In addition, 'absent' was assigned to areas where no Starlings had been observed, irrespective of survey effort. Areas where surveys had not been undertaken in NSW were recorded as unmarked cells on the density map.

3) Survey Effort map – showing 10' areas (approximately 15km x 18km) of survey effort in six categories: 1-20, 21-40, 41-60, 61-80, 81-100% and greater than 100 surveys in a 10' area.

These maps have been produced to represent available information in the most meaningful/interpretable manner.

- Map 1 (Presence/ Absence) was produced to show where starlings were present.
- Maps 2 and 3 need simultaneous examination for accurate interpretation. Starling density has been calculated from reporting rate (which may not always reflect the true abundance of starling numbers in any area given survey effort varies throughout their range). The more surveys or the greater the survey effort, the more reliable the data becomes.
- All maps provide 'snapshots' of the available data on Starlings in NSW.

European Carp

Distribution and abundance of carp were derived from a database of electro-fishing survey records (reported as catch-per-unit-effort) from over 600 stratified sampling sites located throughout the rivers of NSW provided by Dean Gilligan, Research Scientist, NSW DPI. These included many main rivers of the Murray-Darling Basin, rivers throughout the tablelands and slopes regions, coastal rivers and some large lakes/water bodies. These sites were sampled during routine Fisheries surveys between July 2000 and June 2006. Additional information on carp abundance (particularly between sampling localities) were obtained from knowledge of NSW DPI Fisheries staff. The abundance of carp was estimated using an alternative technique to that of terrestrial species, i.e., abundance estimates were based on six years electro-fishing catch-per-unit values (carp caught per hour of electro-fishing) at sample sites (defined as a 1km reach of river).

The following method was used to translate catch-per-unit-effort (CPUE) sampling information to categories for abundance (selected to account for the range and median of CPUE values):
Absent = CPUE less than 1.
Low = CPUE 1-5.
Medium = CPUE 5-50.
High = CPUE 50-500.

All sample point data were courtesy of NSW DPI Fisheries. Data were reported for the main rivers of NSW using 5x5km grid array and projected in ArcView GIS. Where sampling sites were not sufficient to provide a continuous dataset along rivers, the experience and knowledge of NSW DPI Fisheries staff (expert advice) was used to interpolate information (estimate density) between sample points. Ephemeral water bodies and rivers that flow only during infrequent flood events were reported as containing ‘no carp’ due to widespread drought conditions throughout NSW.

Cane toads

Detailed mapping information on the distribution and abundance of established cane toads was captured through a process similar to survey group 1 species and feral cats. Key representatives from the NSW Department of Environment and Conservation (DEC) (National Parks and Wildlife Service) were consulted to report the distribution and abundance of established cane toad populations using a 5x5km grid array. Abundance categories as described in table 2 were used to estimate the distribution and abundance of cane toads in northern NSW. ArcView GIS was used to record data with background landscape features, land tenure and townships to familiarise survey participants with regions for reporting. Expert advice was also sought from relevant independent authorities throughout NSW, including staff from NSW DPI and the Frog Rescue Service.

3.3 Interpretation of mapping outcomes.

These surveys were based on the best available information at the time of data collection. Certain assumptions have been made in the process, as estimates largely represent the judgement of experts within wildlife management Agencies in NSW in the absence of detailed field survey data. Animal populations also naturally fluctuate with seasonal or reproductive cycles, and are regulated by the availability of localised resources. Many species move large distances, migrate or disperse in response to climatic conditions and

stochastic events. Herein, abundance estimates attempt to capture and accurately represent spatial variation in populations, presenting a ‘snap-shot’ of the perceived average population abundance throughout NSW.

This survey utilised a 5x5 km grid array (equating to 25km^2) to record and collate pest animal information. This reporting resolution size accommodates for the spatial distribution and territorial size of most species, as well as variation in habitats, and units appropriate to the allocation of resources for most control programs. Data for starlings has been presented in a slightly larger size (approximately 15x17 km² grid) due to the origin and collection process of the data.

4. SURVEY RESULTS

4.1 Feral pigs (*Sus scrofa*)


Photo G Saunders

Feral pigs in Australia are descendents of domestic pigs introduced to mainland Australia during European settlement. Feral pigs currently inhabit approximately 38% of the continent (Choquenot *et al*. 1996). They occupy a wide range of habitats, but are often found in close proximity to watercourses, and floodplain environments in inland and seasonally dry regions. Because of their low heat tolerance, the availability of water and adequate shelter are important resources for feral pigs (Choquenot *et al*. 1996). A number of characteristics have allowed feral pigs to be successful colonists of mainland Australia. They usually breed seasonally, but may breed all year round depending of resource availability. Females can breed twice per year and produce between five and six offspring, allowing populations to increase rapidly when conditions are favourable. They are a mobile species that respond to changes in food and water availability. Feral pigs are also opportunistic omnivores that have a varied diet ranging from carrion, tubers, roots, seeds, fruit and invertebrate prey (NSW Scientific Committee 2004a). These characteristics enable feral pigs to survive in many different habitats, including tropical savannah, semi-arid rangelands and sub-alpine tundra. Conditions that influence the density of feral pigs throughout their range include the carrying capacity of landscapes, recent climatic conditions, land management practices, as well as current and previous levels of control.

Distribution

Feral pigs are widely distributed throughout the western division and northern slopes, abundant in the central slopes, northern and southern tablelands, and fragmented within the southern slopes, south and north coast regions of NSW (figure 1). Although the abundance of feral pigs varies greatly across the State, they are present in all Rural Lands Protection Board Districts, therefore current legislation requires feral pigs to be controlled in all districts. The distribution of feral pigs is mainly concentrated in the western division of NSW, (88% inhabited), and the northern slopes division (92% inhabited). There are many small unconnected populations of feral pigs throughout other areas of NSW, including the southern and central slopes divisions, as well as along the coastal fringe of the state.

Since 2002 feral pigs have marginally increased the total area they inhabit, and currently occupy 63% of NSW and the ACT (table 3), despite the perception that they had decreased in many RLPB Districts (figure 2). Changes in the abundance of feral pigs were reported from many fragmented areas of the State (representing approximately

39,000km^2 of NSW) (appendix 3). Small to moderate increases in feral pig abundance were reported in the far west, northern plains, northern tablelands, Hunter and south-west slopes regions of NSW (appendix 3). Slight decreases were also observed within some parts of these regions, as well as the Blue Mountains and south coast regions (appendix 3). Although feral pigs were at low density throughout most of their range, the total area containing high feral pig density has increased since 2002 (table 3). Many regions of NSW have experienced below-average rainfall in recent years, which might have resulted in localised declines in feral pig density during this time. However, feral pig numbers have seemingly endured these conditions throughout much of their range. In many areas, marginal increases were also reported in the range and abundance of feral pigs. This is likely to be the result of an inability of many landholders to undertake control programs during recent years. Eleven Rural Lands Protection Districts reported a reduction in the levels of feral pig control work as a result of drought and widespread plague locust outbreaks. Reliance on Government support was also reported as a reason for declined levels of control in some areas. These factors may have contributed to the observed increase in feral pig distribution throughout NSW.

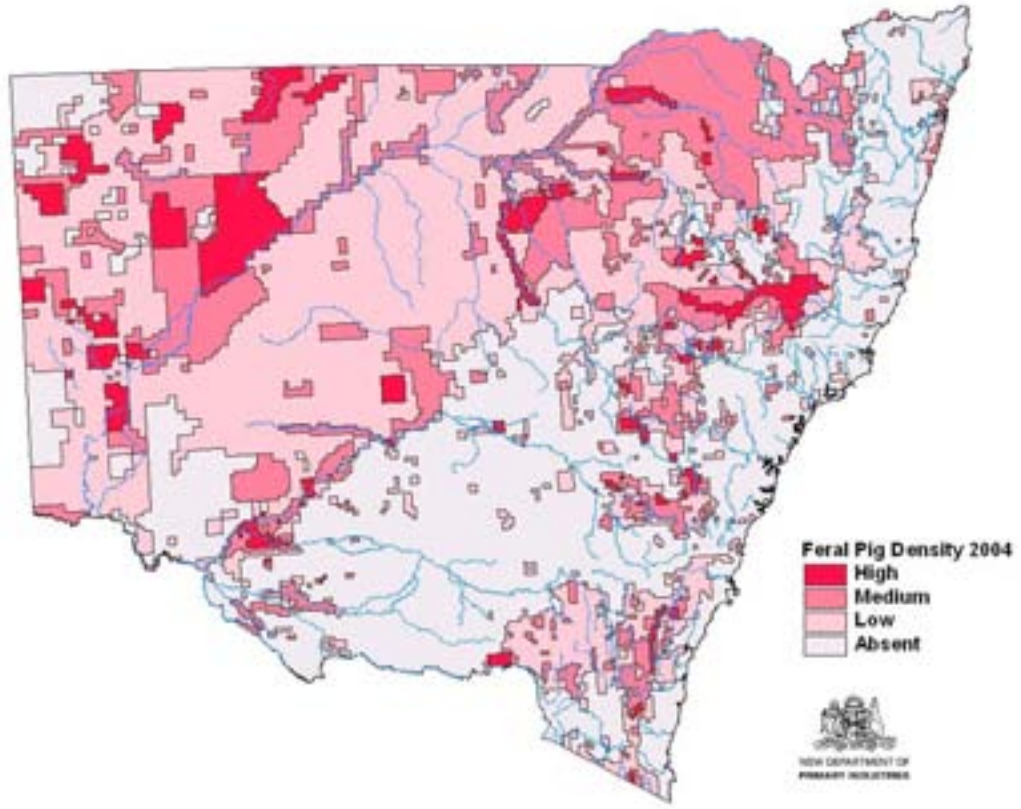

Figure 1. Density of feral pigs (*Sus scrofa*) throughout NSW and the ACT during 2004.

Table 3. Area inhabited by feral pigs throughout NSW (km^2) (percentage areas in brackets).

Year	**Density km^2 (percent of NSW)**				
	High	**Medium**	**Low**	**Absent**	**Total occupied**
2004	44 375 (6)	149 762 (18)	312 671 (39)	297 194 (37)	506 808 (63)
2002[1]	39 684 (5)	148 433 (18)	312 283 (38)	316 914 (39)	500 400 (61)

[1] West and Saunders (2003)

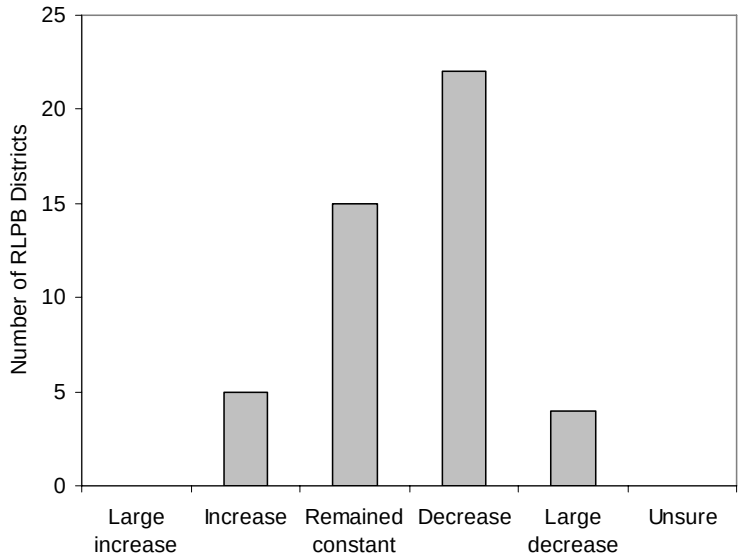

Figure 2. Perceived change in feral pig populations within the RLPB Districts of NSW since 2002.

Impacts

Feral pigs cause a wide range of adverse impacts to the environment, agricultural industries, society and the economy. They are a declared pest animal under the Rural Lands Protection Act (1998), and predation, habitat degradation, competition and disease transmission by feral pigs has resulted in the species being listed as a key threatening process for biological diversity conservation under the NSW Threatened Species Conservation Act (1995) and the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). Feral pigs also spread weeds, prey on wildlife (Pavlov 1995), damage sensitive wetlands, and threaten the survival and abundance of native species and communities (DEH 2004a). In the agricultural sector, feral pigs prey on new-born lambs, foul valuable water sources, carry and spread parasites and disease and damage fences. Importantly, they are often found close to livestock, scavenge on refuse and carcasses, and have to ability to move long distances over a relatively short time. These attributes imply that feral pigs may be as a wildlife species of high potential risk in the event of exotic animal disease incursions, such as foot-and-mouth disease. Feral pigs may also act as reservoirs for wildlife disease that can affect humans, such as Trichinellosis, Brucellosis, and Leptospirosis (McLeod 2004).

It is difficult to accurately estimate the total economic costs of damage caused by feral pigs throughout Australia, however, damage may exceed $100 million annually (Choquenot *et al*. 1996, McLeod 2004). Their long-term adverse impacts of feral pigs on land degradation also remain largely un-estimated. The direct costs of control in response to their impacts on agriculture and the environment are also substantial. The control of feral pigs is generally expensive and labour intensive. Bomford and Hart (2002) estimate that the management costs associated with feral pig control cost an estimated $5 million annually throughout Australia, however, there are no definitive estimates available for NSW. Although the impacts of feral pigs remain largely unquantified, understanding relationships between feral pig density and damage has been the focus of some research modelling. In this report, information is presented on abundance and impacts at the

district level. While such data does not provide true density-damage relationships it does increase our understanding of the processes involved. This will be important for regional and catchment-based feral pig management planning.

According to the survey participants, the greatest impacts of feral pigs throughout NSW during 2004 included pasture damage, soil erosion and land degradation, exotic disease risk, damage to watercourses, and crop damage (figure 3). There were no significant changes in the observed impacts between 2002 and 2004, however slight increased were observed in the reported impact of feral pigs on watercourses and lamb predation since 2002 (figure 3). Increased levels of damage to watercourses may be a result of continuing dry climatic conditions throughout much of NSW. Pigs often foul water sources used for livestock, and can significantly impact on sensitive wetland habitats when water is in short supply. Increased levels of lamb predation may also be the result of dry climatic conditions, as pigs search for alternate sources of food when resources are scarce. Reductions in other impacts may be directly associated with localised increases in the level of control.

The impacts of feral pigs vary greatly between districts of NSW (figure 4). For example, crop damage throughout the northern and central slopes divisions was substantially higher than elsewhere in NSW (figure 4). Despite a slight increase in feral pig distribution and abundance throughout NSW since 2002, land managers reported that the impacts of feral pigs have remained constant or decreased throughout their range (figure 5). This may mean that trends in observed damage levels may not necessarily imply a corresponding trend in animal density, and caution is required when making decisions based on either type of information.

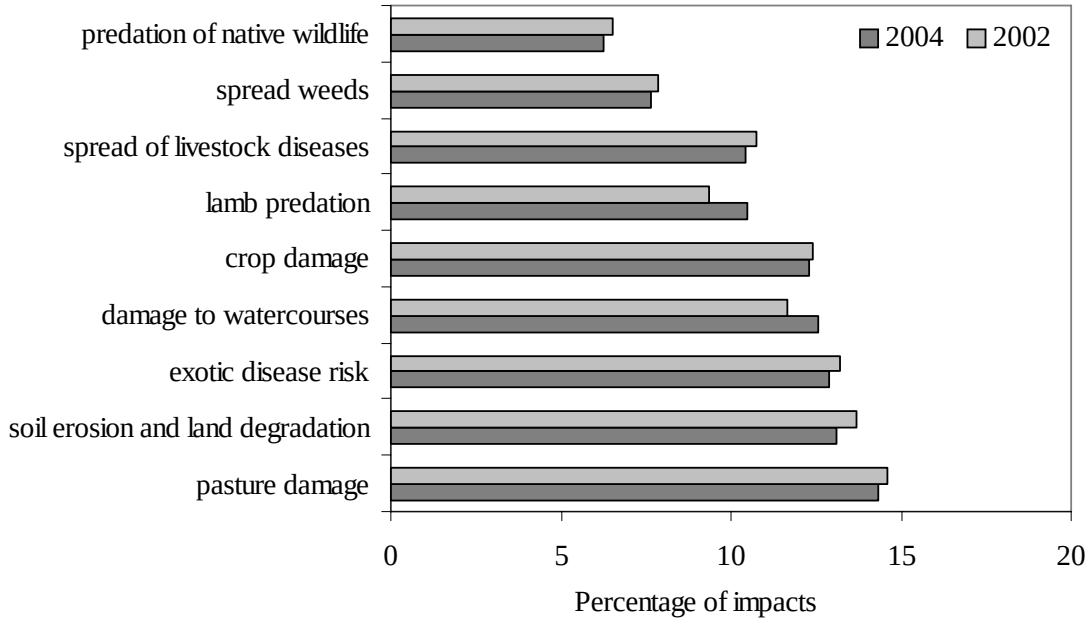

Figure 3. Perceived impacts of feral pigs throughout NSW during 2002 and 2004.

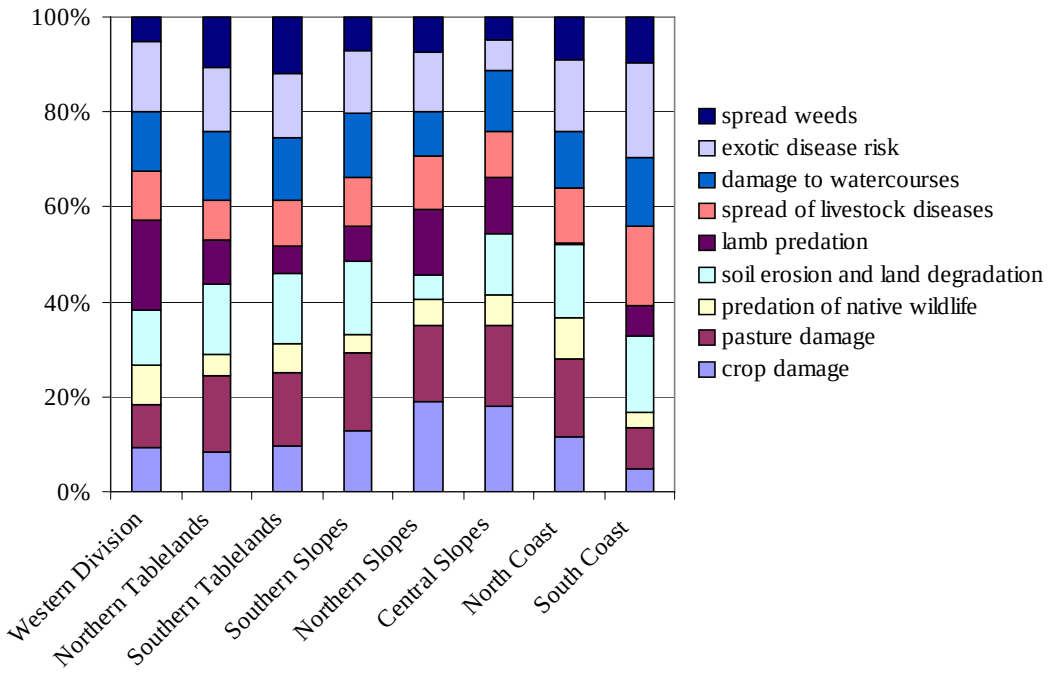

Figure 4. Perceived impacts of feral pigs throughout Divisions of NSW during 2004.

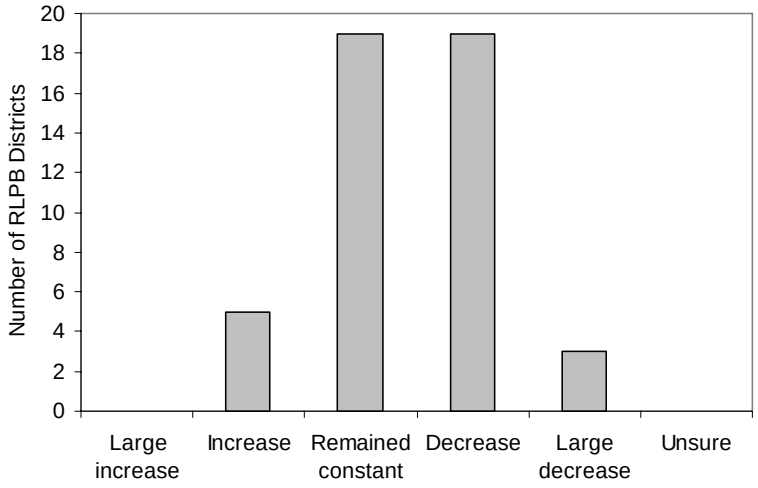

Figure 5. Perceived change in feral pig impacts throughout the RLPB Districts of NSW since 2002.

Control

There are a wide range of well-tested control techniques available for feral pigs throughout Australia, of which 9 were used throughout NSW during 2004/05. According to the RLPB Districts, trapping represented the most commonly used technique (31.2%) in agricultural areas, followed by recreational hunting (22.3%) and poison baiting with 1080 (sodium monofluoroacetate) (12.6%) (figure 6). While the use of control techniques was comparable to 2002, the use of trapping and aerial shooting increased marginally, and ground shooting and poisoning with 1080 declined. The use of poison baiting with CSSP, recreational hunting, commercial harvesting, exclusion fencing, and the use of Judas pigs remained similar to 2002 (figure 6).

The use of control techniques for feral pigs varied throughout the Divisions of NSW (figure 7). Commercial harvesting remains a commonly used method throughout the northern slopes and northern tablelands divisions (figure 7), and is absent within the north coast, south coast and southern slopes divisions. Poison baiting with CSSP remains largely restricted to the western division and northern tablelands of NSW (figure 7), where regular collection of prepared 1080 baits is generally not feasible for landholders. Poison baiting with 1080, ground shooting, recreational hunting and trapping are widely used throughout NSW (figure 7). Variation in the use of control techniques is almost certainly the direct result of the costs associated with each technique, personal preference, available training and skills, and the suitability of each technique for feral pigs within each division determined over many years. Although levels of feral pig control throughout the past 2 years increased in some areas and decreased in others, perceived levels of control remained relatively constant throughout most of the State (figure 8).

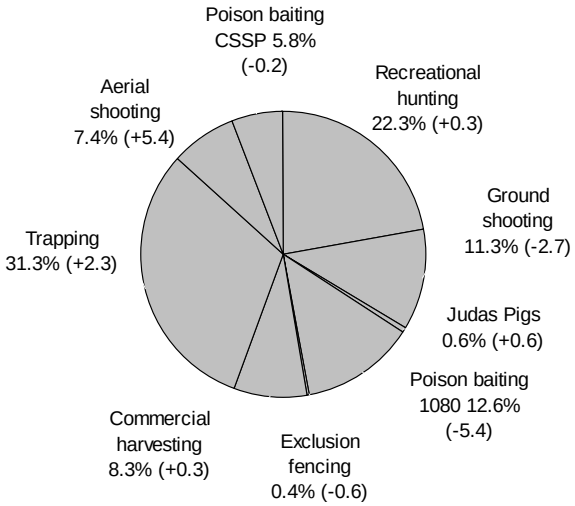

Figure 6. Use of control techniques for feral pigs throughout NSW during 2004 (change since 2002).

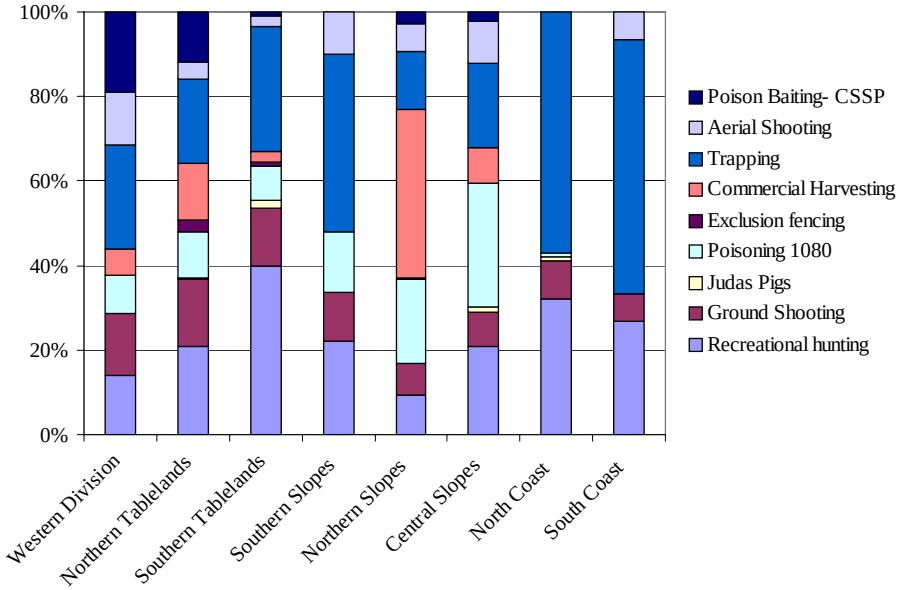

Figure 7. Use of control techniques for feral pigs throughout Divisions of NSW during 2004.

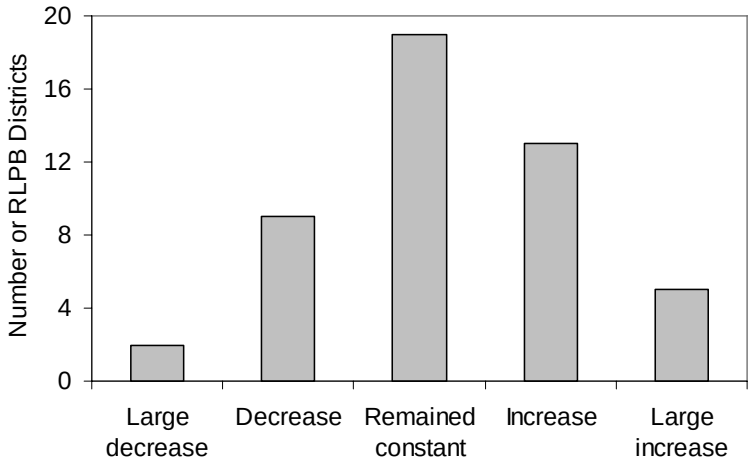

Figure 8. Perceived change in the levels of control in the RLPB Districts of NSW since 2002.

Management Summary

Feral pigs remain widely distributed throughout all Divisions of NSW despite state-wide drought, and intensified control in some areas. Since 2002, feral pigs have marginally increased their total range and inhabit over 506,000km^2 (63%) of NSW. The current survey has revealed that there are more areas classified as containing a high density of feral pigs than in 2002, possible culminating from several years of drought making it financially difficult for many farmers to undertake control programs. Drought relief funding during the peak of drought has apparently had little bearing on the range and density of feral pigs, yet their impacts have notably lessened. All Divisions of NSW, with the exception of the south coast division, have seen an increase in the range of feral pigs. Feral pigs continue to expand into new areas and recolonise areas where recent control has been successful. Limited follow-up control and illegal activities such as transportation and release of feral pigs are considered factors that have contributed to this trend.

Between 2002 and 2005, many landholders faced significant hardship as a result of drought conditions, locust plagues, and in some cases large bush fires. While feral pig populations are likely to have been affected by these events, many landholders were reportedly unable to undertake control during these periods. Drought assistance funding was provided throughout western NSW to landholders through the Rural Lands Protection Board Districts to assist with trapping and aerial shooting of feral pigs. Not surprisingly, the overall use of these techniques increased in contrast to 2002 (figure 6). However, feral pig populations are well-known to recover quickly when resources are plentiful, and the control campaign has not appeared to have had a long-term reduction in the density of feral pigs throughout western NSW. Reliance on drought assistance was implicated as a reason for an observed reduction in other control programs which may have allowed for a partial or full recovery of feral pig numbers.

Best-practice pest animal management encourages the use of a wide range of control techniques within a strategic framework. Given private recreational hunting and commercial harvesting constitute over 30% of control technique use throughout NSW, it seems appropriate to integrate these techniques within a well-organised control

framework administered by regional pest animal managers. Selecting the most suitable control techniques to minimise the impacts of feral pigs is a priority for land managers. Equally important is the need to determine the response of feral pigs to levels of control, as well as monitor the success of control programs using appropriate monitoring techniques. Common monitoring techniques for feral pigs include dung counts, aerial surveys, and measuring the abundance of sign such as ripping. The success of control programs for feral pigs (and all pest species) in areas where populations are widespread, abundant and mobile relies almost entirely on a collaborative and simultaneous effort involving many landholders. Relief from the long-term impacts of feral pigs can only be achieved if a strategic and collaborative on-going control program is adequately resourced, coordinated and monitored.

4.2 Feral goats (*Capra hircus*)


Photo P O'Brien

Feral goats in Australia are descendents of various breeds of domestic stock introduced in 1788 by European settlers and on many subsequent occasions (DEH 2004b, Henzell 1995). They are currently found in all States and Territories of Australia and many offshore islands, with the exception of the Northern Territory (Parkes *et al*. 1996). Feral goat populations have established from escaped or released domestic animals, and more recently from animals released to control weeds (McLeod 2004). Feral goats are generalist herbivores that graze and browse a variety of food types including pastures, foliage, twigs, bark and fruit (NSW Scientific Committee 2004b). They can withstand long periods of drought, and move large distances between food and water resources. Feral goats usually form herds, but males and females live separately for much of the year. Breeding is dependent on food availability, and females can breed twice per year allowing populations to increase quickly when resources are abundant. Feral goats are found in many areas of NSW, including arid and semi-arid rangelands, as well as higher rainfall and agricultural areas of eastern NSW. They have benefited from sheep grazing practices and the provision of artificial water points throughout the dryer regions of NSW. In 2002, feral goats inhabited 37% of NSW and the ACT (West and Saunders 2003). Although the majority of feral goats exist throughout western NSW, many isolated populations also occur throughout the northern and southern tablelands (Parkes *et al*. 1996, West and Saunders 2003).

The impacts of feral goats include losses to agricultural production, damage to the environment, and impacts on society. *Competition and land degradation by feral goats* has been listed as a key threatening process in Australia under the Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act), and in NSW under the Threatened Species Conservation Act (1995). The damage caused by feral goats to pasture costs Australian producers an estimated $20 million annually, and there are also sizable costs associated with the control of feral goats (McLeod 2004). Estimates for control costs would be substantially higher if the costs of commercial harvesting operations were included. Feral goats are also often found in close association with domestic sheep, raising concern that they may transmit or maintain contagious diseases such as foot-and-mouth disease. Although feral goats are a pest species, they are also commercially harvested in many regions of NSW and represent a valuable commodity when game meat prices are high.

Distribution

Feral goats are widely distributed throughout the western division, locally abundant in the northern and central slopes, and scattered throughout the tablelands and coastal regions of NSW (figure 9). Since 2002, feral goats have expanded their range slightly, and currently inhabit 38% of NSW and the ACT (table 4). Feral goats mainly occur at low and medium

densities throughout their range, but some high density populations can be located in regions of north-western NSW and small areas within the northern, central and southern slopes regions (figure 9).

Changes in the abundance of feral goats were reported from approximately 56,000km^2 of the State. Small increases were detected in the lower-darling region of south-western NSW, and the upper-darling and northern plains region (appendix 3). Several small areas scattered throughout the northern plains, northern tablelands and hunter regions also experienced small increases (appendix 3). At the same time, small decreases were observed in wide areas throughout the upper-darling and far-west regions, and in many small locations throughout the south coast, Snowy Mountains, Blue Mountains, and central slopes regions (appendix 3). Observed decreases in density throughout western NSW are likely to be a two-fold result of drought and commercial harvesting operating in that area. Despite the drought conditions experienced throughout NSW during previous years, feral goats have remained abundant throughout much of the State.

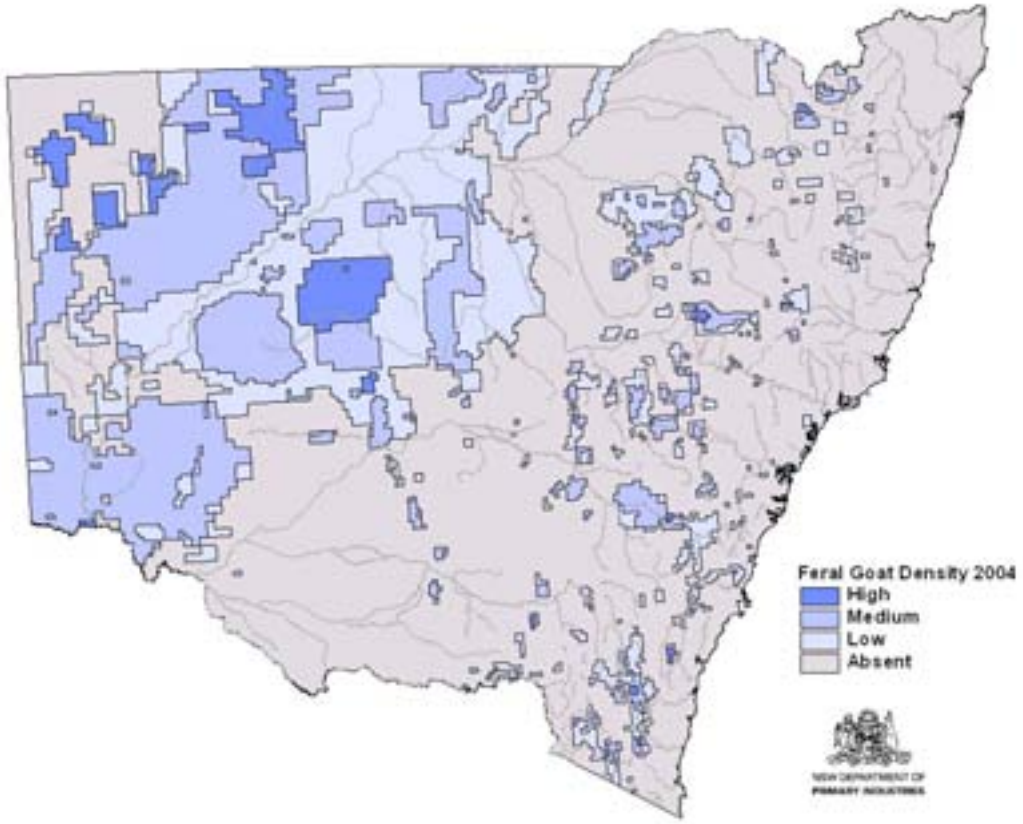

Figure 9. Density of feral goats throughout NSW and the ACT during 2004.

Table 4. Area inhabited by feral goats throughout NSW (km^2) (with percentage areas in brackets).

Year	**Density km^2 (percent of NSW)**				
	High	**Medium**	**Low**	**Absent**	**Total occupied**
2004	23 628 (3)	133 932 (17)	149 509 (18)	496 923 (62)	307 069 (38)
2002[1]	32 153 (4)	110 016 (13)	164 509 (20)	512 811 (63)	306 678 (37)

[1] West and Saunders (2003)

Impacts

Feral goats cause large economic losses to agricultural production, damage the environment, and impact on social values/assets. The economic-related impacts of feral goats in NSW include losses to production through competition for pasture, transmission of livestock disease and damage to infrastructure, such as fences. The environmental impacts of feral goats in NSW include damage to native vegetation, spread of weeds, and erosion and land degradation (Henzell 1995, NSW Scientific Committee 2004b), although these may also lead to substantial long-term economic losses. The adverse social impacts of feral goats include the risk of exotic disease, losses associated with repairing damage caused by feral goats, damage to heritage sites (NPWS 2003), and losses associated with controlling feral goats. However, feral goats also present economic and social value as a commercial harvesting resource. It should be noted that the positive impacts are unlikely to outweigh the adverse impacts in NSW, particularly if long-term land degradation is considered. The long-term impacts of feral goats remain difficult to establish, such as gradual change to the composition of vegetation communities. There are also additional costs associated with controlling feral goats, and costs associated with preventing impacts. A recent study on feral goats in NSW has revealed that there are in some cases sufficient levels of interaction between domestic sheep and feral goats to facilitate transmission of contagious diseases, raising further concern that feral goats may spread foot-and-mouth disease if it were introduced to Australia (Fleming 2005).

During 2004, the main impacts of feral goats consisted of damage to native vegetation, competition for pasture, spread of livestock disease, and exotic disease risk (figure 10). Other impacts included the fence damage, spread of weeds, and erosion and land degradation (figure 10). In contrast to 2002, feral goats were seen as having a greater impact through competition for pasture during 2004 (figure 10). It was thought that spread of livestock disease and exotic disease risk were less important in 2004 (figure 10), and all other impacts of feral goats remained relatively even between 2002 and 2004 (figure 10). Despite their adverse impacts, feral goats are also commercially harvested for the game meat industry throughout NSW and represent an important commodity within 17 Districts of the State (table 5). As a result, feral goats are not always considered an undesirable species.

The impacts of feral goats vary greatly throughout the Districts of NSW (figure 11). For example, the spread of weeds by feral goats in the north coast district represented the lowest impact, but represented a much higher impact in the southern tablelands. Competition for pasture also represented the greatest negative impact of feral goats in the western division, but the lowest impact in the south coast division. Recognising that the impacts of feral goats (and their commercial value) varies throughout the State is important when developing and implementing policies and practices for control.

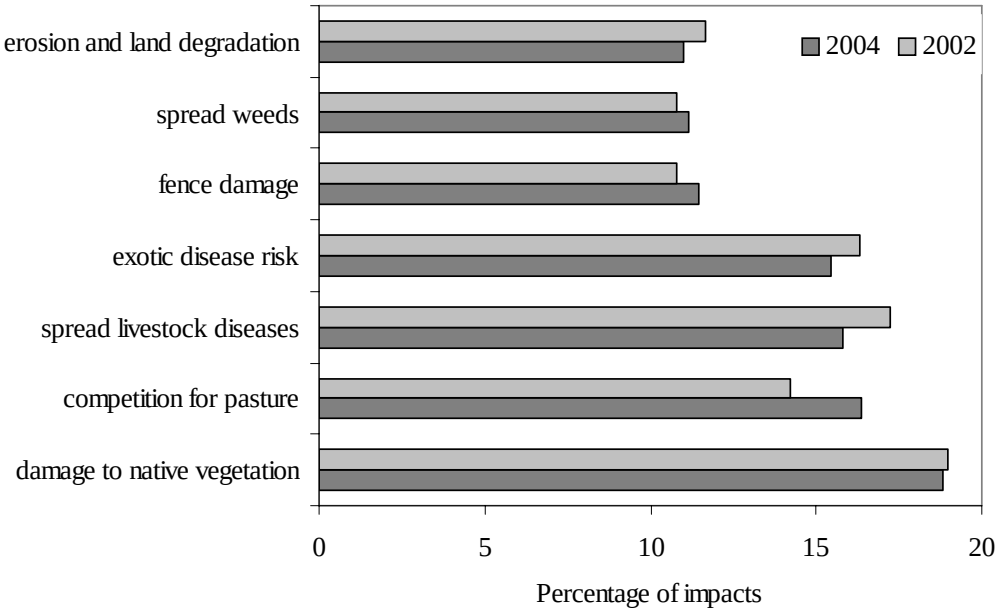

Figure 10. Perceived impacts of feral goats throughout NSW during 2002 and 2004.

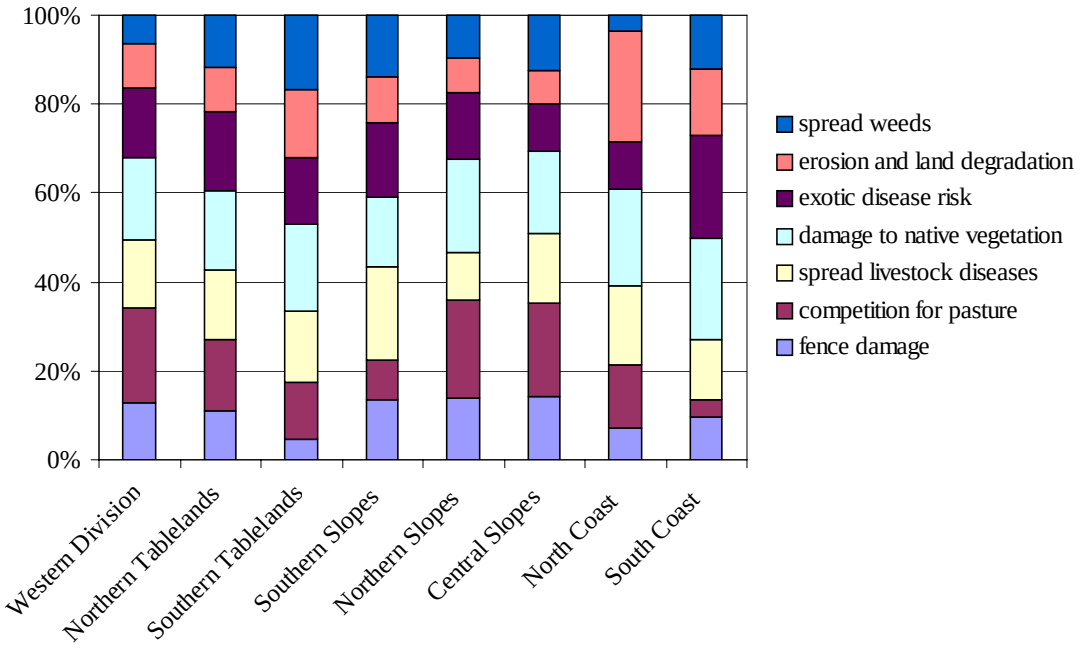

Figure 11. Perceived impacts of feral goats throughout Divisions of NSW during 2004.

Control

There are a wide range of techniques available to control feral goats throughout Australia. The most commonly used techniques to control feral goats in the agricultural regions of NSW are mustering, ground shooting, and aerial shooting (figure 12). Other techniques used include trapping (usually at water), exclusion fencing, and the use of Judas goats (figure 12). Between 2002 and 2004/05, declines in the use of ground shooting and other unspecified techniques resulted in an overall increase in the proportional use of all other methods (figure 12). However, this does not mean that the overall control effort to reduce the impacts of feral goats has also increased, and caution is required interpreting these findings.

Locating feral goats within inaccessible areas or at low densities presents a significant problem for the implementation of control programs. Of the techniques used to control feral goats in inaccessible areas, aerial shooting is the most suitable. Mustering or trapping are generally considered unsuited to steep or rugged terrain, or heavily vegetated areas. The use of Judas goats is also a technique for locating populations in inaccessible areas, or where they are otherwise difficult to locate. Applying an integrated approach by using a number of control techniques simultaneously is considered the best way to optimise the effectives of a control program.

Mustering is the main technique used in commercial harvesting throughout NSW. It is usually undertaken in easily accessible areas, where large numbers of feral goats can be herded towards a central location. It should be noted that while mustering is usually an expensive and labour intensive technique, income from mustering and commercial harvesting often off-sets the cost of mustering, supplying participating landholders with a value economic return. In 2004, mustering represented 63% of all control used in the Western Division, which was marginally higher than 2002 (figure 12) (West and Saunders 2003).

During 2004, there was large variation in the use of control techniques throughout divisions of NSW (figure 13). For example, the use of ground shooting ranged from 3% to 100% (figure 13). There was also marked variation in the use of mustering (the most commonly used technique) throughout NSW (figure 13). It is unclear why the use of techniques varied largely between Divisions, however one possible explanation for this trend is that most feral goat control techniques have specific requirements. For instance, mustering is most suited to accessible terrain, and is only economically viable above a certain goat density.

Table 5. Number of RLPB Districts within NSW where commercial harvesting of feral goats takes place.

Commercial harvesting is present	17
Commercial harvesting is absent	31

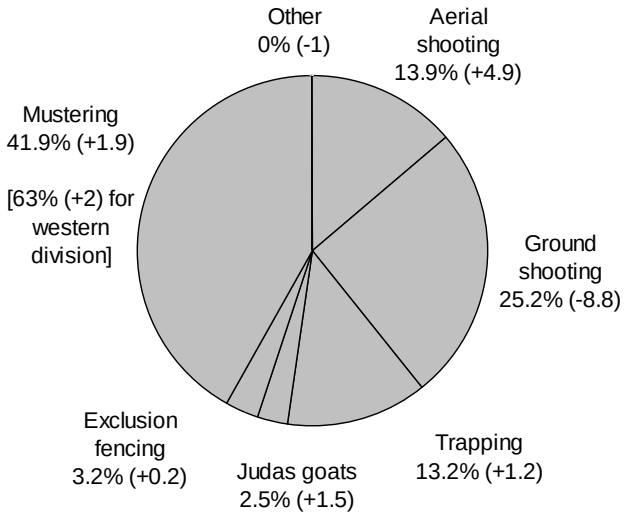

Figure 12. Use of control techniques for feral goats throughout NSW during 2004 (change since 2002).

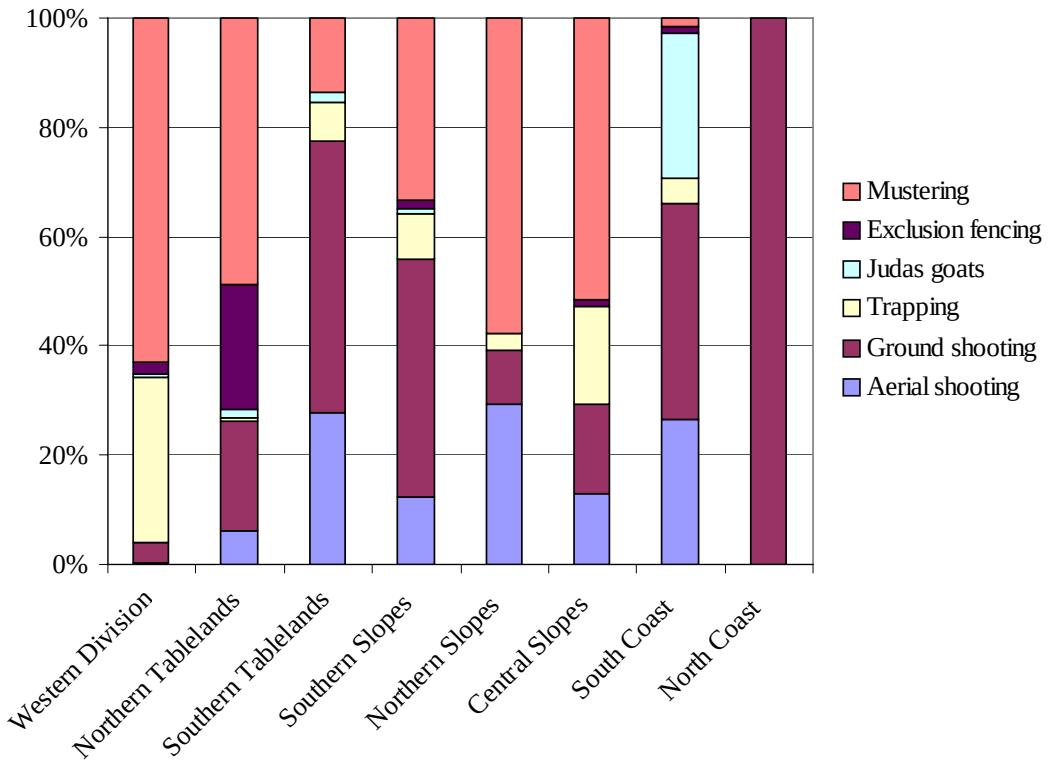

Figure 13. Use of control techniques for feral goats throughout Divisions of NSW during 2004.

Management Summary

Feral goats remain abundant throughout many vast areas of NSW. The total distribution of feral goats covers over 307,000km^2 (38%) of the State. They occur mainly at low and medium densities, and have slightly increased their total range since 2002. Recent widespread drought has made it difficult for many landholders to undertake control, and as feral goats can generally withstand extended dry periods (Parkes *et al*. 1996), this presents one possible explanation for the observed increase in feral goats over recent years. As feral goats are a wide-ranging species, maintaining separation between small seemingly isolated populations, and reducing their ability to move large distances to exploit localised resources should also be considered priorities for regional management.

Mustering and commercial harvesting remain invaluable techniques for feral goat control throughout NSW. Coordination of mustering between many landholders and properties can be highly effective in quickly reducing large feral goat populations. While feral goats cause widespread economic and environmental damage, it is important to recognise their value for commercial harvesting. However, feral goats should not be harvested for sustainable management, but rather to rapidly knock-down their abundance providing income as a bonus. Best-practice pest animal management encourages the use of a wide range of control techniques within a strategic framework. Mustering represents a valuable tool for feral goat control, and if used with other techniques in a strategic control program, should effectively reduce the numbers and impacts of feral goats. Monitoring the success of control programs using appropriate techniques is also essential. Monitoring is a valuable way to identify how to reduce the costs of control, while reaching desired control outcomes.

4.3 Wild deer (6 species and hybrids).

Domestic deer were initially introduced to Australia during European settlement and thereafter for the purposes of farming, local aesthetics and sport (Bentley 1998, Moriarty 2004). Escaped or released deer established wild populations and have now become a nuisance in many areas. Wild deer, also commonly referred to as 'feral deer', are found in all States and Territories of Australia. In NSW, wild deer include 6 species: fallow (*Dama dama*), red (*Cervus elaphus*), sambar (*Cervus unicolour*), rusa (*Cervus timorensis*), chital (*Axis axis*) and hog (*Axis porcinus*). Although records of these individual species were collected in this survey, all species have been combined in this report to depict the distribution and abundance of all wild deer in NSW, primarily because their management is not currently species-specific. Where species-level information may be important for wild deer management, it is recommended that mapping individual species should be undertaken wherever possible.

Photo: B Boyle

Wild deer have long been known to inhabit the eastern districts of NSW in largely isolated populations, and mainly concentrated in the south-east and north-east of the State (Strahan 1995). However, the detection and reporting of wild deer from many other regions in recent years has determined that wild deer inhabit substantially larger areas than was once thought (West and Saunders 2003). Although translocation of wild deer accounted for the dispersal of wild deer into remote areas during the early 1900s, the deliberate release and accidental escape of farmed deer apparently account for more recent introductions of domestic deer into the wild throughout NSW (Moriarty 2004).

During 2002, the area inhabited by wild deer species accounted for approximately 40,700km^2 (5%) of NSW (West and Saunders 2003). Evidence and anecdotal reports at the time of the 2002 survey suggested that their range, abundance and associated impacts were increasing throughout NSW. Although very little is known about their impacts, spread of livestock disease; competition for pasture; crop damage; and damage caused to motor vehicles on the road were reported during 2002. Wild deer are also known to ring-bark trees, accelerate soil erosion and foul water holes. In NSW, *herbivory and environmental degradation caused by feral deer* has been listed as a key threatening process under the Threatened Species Conservation Act 1995. While the adverse impacts of wild deer are numerous, they are also valued as a recreational hunting resource.

Distribution and behaviour

Wild deer are distributed widely throughout the Coast and Tablelands Divisions of NSW, and less common throughout the Slopes and Western Divisions (figure 14). According to survey participants, wild deer occur mainly in moderately sized disconnected populations throughout

the Great Dividing Range and along the coastal fringe of the State. Throughout the Slopes of NSW, their distribution is mainly restricted to small populations; however there are many areas where wild deer were reputedly increasing (appendix 3). Wild deer have increased in numerous areas throughout the northern, central and southern slopes districts, and in many areas in the coastal districts of NSW (appendix 3). Their range extends into far-western NSW, but numbers are reportedly very low. In eastern NSW, wild deer occasionally occur in very large herds (Moriarty pers. comm.).

Between 2002 and 2004/05, changes in the abundance of wild deer were reported from approximately 17,400 km^2 of the State (appendix 3). In most cases these changes represent increases in animal abundance and reports from 30 new locations throughout NSW (equating to an increase in total range by over 8000 km^2 – see table 6). These figures suggest that the abundance and range of wild deer has increased more than any other pest species. During 2004/05, wild deer were reported as occurring mainly at low densities in NSW, however areas classified as high density had increased substantially since 2002 (table 6). The control of wild deer in most Districts has been in response to damage, or applied in conjunction with other control programs. Illegal activities, such as the deliberate release and translocation of domestic deer have allegedly contributed to increases in wild deer numbers and new records throughout many regions. A rise in general awareness of wild deer may also contribute to such observed trends.

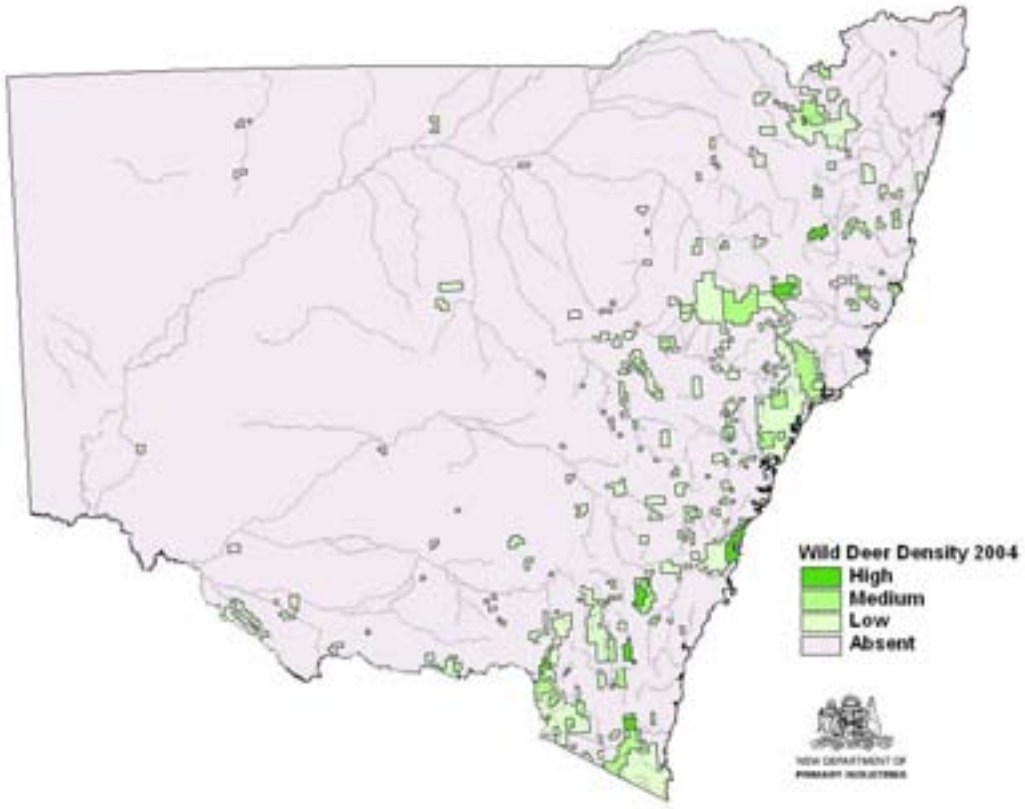

Figure 14. Density of wild deer throughout NSW and the ACT during 2004.

Table 6. Area inhabited by wild deer throughout NSW (km^2) (with percentage areas in brackets).

Year	Density km^2 (percent of NSW)				
	High	**Medium**	**Low**	**Absent**	**Total occupied**
2004	2 430 (<1)	10 893 (1)	35 652 (4)	755 020 (94)	48 975 (6)
2002[1]	616 (<1)	10 714 (1)	29 387 (3)	779 364 (95)	40 717 (5)

[1] West and Saunders (2003)

Wild deer are often thought to move only short distances between feeding and sheltering areas. When asked about the distribution and behaviour of wild deer throughout the Districts of NSW, most of the survey respondents (n=29) reported that wild deer were localised to small areas, while others (n=6) reported that wild deer were scattered and widespread (table 7). Similarly, wild deer were most commonly observed in groups between 3 and 10 individuals (n=21), and solitary (n=10). Groups over 10 in size were not common (n=4) (table 7). Although wild deer are considered highly mobile and have the potential to move large distances quickly, most survey respondents considered deer as only moving short distances (n=15) (table 7). These findings indicate that there is considerable variation in the behaviour of wild deer throughout their current range; an aspect that evidently needs to be considered in their management. In terms of the types and frequency of observations made on wild deer, most observations of wild deer occur in similar locations, and every few months (table 7). However, there was considerable variation in observations (table 7).

Detection of wild deer is largely reliant on incidental sightings and observations rather than dedicated survey initiatives. Reports by landholders about the damage caused by wild deer (n=20), and incidental reports from a range of groups (namely hunters, motorists, other land management agencies, landholders, and the general public) (n= 19) represent the best methods for detecting wild deer throughout NSW at present (table 7).

Impacts

Wild deer are thought to be responsible for a wide range of economic, environmental and social impacts. Although deer have been present in the wild for over a century, the long term impacts of wild deer are poorly understood. *Herbivory and environmental degradation* are impacts that are recognised as a key threatening process for biodiversity in New South Wales under the *Threatened Species Conservation Act* 1995.

In NSW, the primary impacts of wild deer may include exotic disease risk, competition for pasture, spread of livestock disease, and crop damage (figure 15). Other impacts include damage to fences, the spread of weeds and damage caused during motor vehicle accidents (figure 15). In contrast to 2002, the overall impacts related to competition for pasture and damage to crops and fences have increased, while others such as exotic disease risk, and the spread of livestock disease have subsequently decreased. The recent drought may have contributed to this shift in perceived impacts towards pastoralist activities, such as competition for pasture, and damage to crops and fences as wild deer feed in areas relied on by graziers.

Table 7. Trends in the observations and behaviour of wild deer throughout NSW from responses by survey participants.

Geographic area	Number of responses
Deer are localised to small areas within our management area	**29**
Deer are evenly distributed throughout our entire management area	0
Deer are widespread and scattered throughout all of our management area	6
Observation location	
Deer are rarely observed in the same places	8
Deer are occasionally observed in the same places	13
Deer are always observed in the same places	**15**
Group size	
Deer are most commonly seen solitary	10
Deer are most commonly seen in pairs	4
Deer are most commonly seen in groups of 3-10 individuals	**21**
Deer are most commonly seen in groups of 11-20 individuals	1
Deer are most commonly seen in groups of 21-40 individuals	2
Deer are most commonly seen in large groups of greater than 40 individuals	1
Movements and mobility	
Deer are immobile and move very little within our District	6
Deer are mobile and move short distances within our District	**15**
Deer are mobile and move moderate distances in our District	13
Deer are extremely mobile and move very large distances in our District	1
Deer are observed by staff / reported to staff by the public (e.g. motorists):	
Daily	1
Weekly	6
Monthly	5
Every few months	**13**
Once a year	8
Less than once a year.	5
The best methods for detecting deer in our District are:	
Reports from landholders where damage is occurring	**20**
Incidental reports from hunters / motorists / land holders / other Agencies / public	19
Organised ground searches involving many people, resources and time	0
Concurrent pest animal management activities (e.g. shooting activities)	5
Other - e.g. property inspections by staff	4

The impacts of wild deer vary considerably throughout NSW (figure 16). The spread of weeds is greatest within the Central Slopes Division, and least within Western Division (figure 16). Similarly, deer-related vehicle accidents are greatest in the North Coast Division, and least in the Northern Tablelands (figure 16). Despite this variance, some consistencies include similar levels of damage between districts for fence damage, crop damage and spread of livestock disease (figure 16). It is possible that poor understanding of many of the impacts of wild deer may lead to a perception that the impacts are occurring in almost-equal proportions. Unlike many pest species, the spatial and temporal impacts of the 6 wild deer species have also not been well-identified. There are also a range of emerging problems associated with wild deer. The magnitude, cause and costs associated with these types of impacts have remained largely un-estimated.

Wild deer are often perceived as posing a serious threat to the transmission and maintenance of exotic disease. In NSW, exotic disease risk rated highest during both 2002 and 2004. Wild deer are susceptible to many livestock diseases, but their role in an exotic disease outbreak is unclear according to many animal health authorities. This highlights the importance of

applying caution while interpreting perception-based information, and a simultaneous need for research and communication of deer disease risks to pest animal managers.

There are many impacts caused by wild deer that have not been highlighted in this report. Wild deer may damage sensitive vegetation communities, ring-bark trees, and even gradually change the composition of vegetation over long periods. At high densities, wild deer can also cause soil erosion, foul water holes, and form trails (pads) similar to those formed by feral horses. Identifying the types and magnitude of impacts caused by wild deer in NSW is a research priority for the development of effective management strategies to address those impacts.

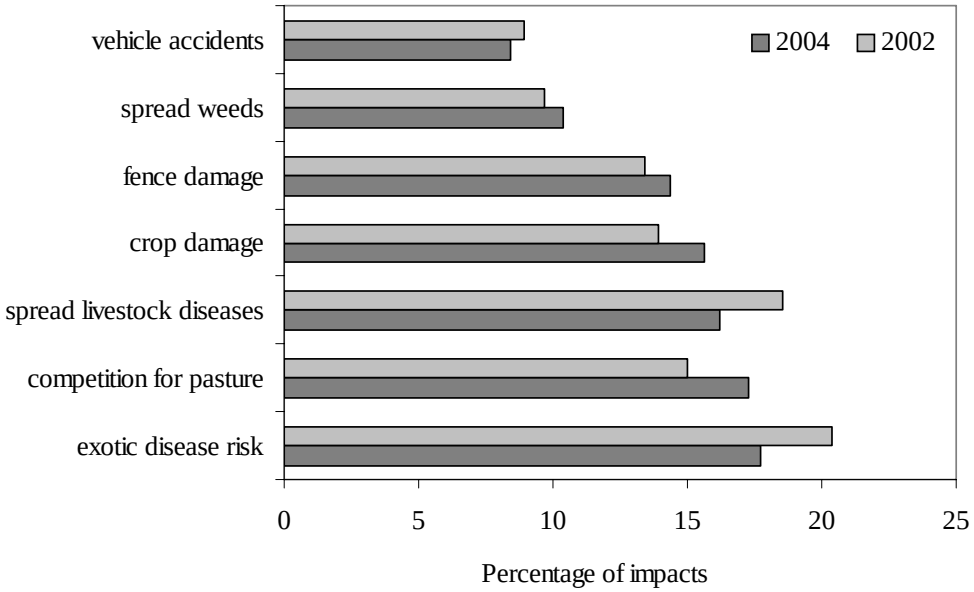

Figure 15. Perceived impacts of wild deer throughout NSW during 2002 and 2004.

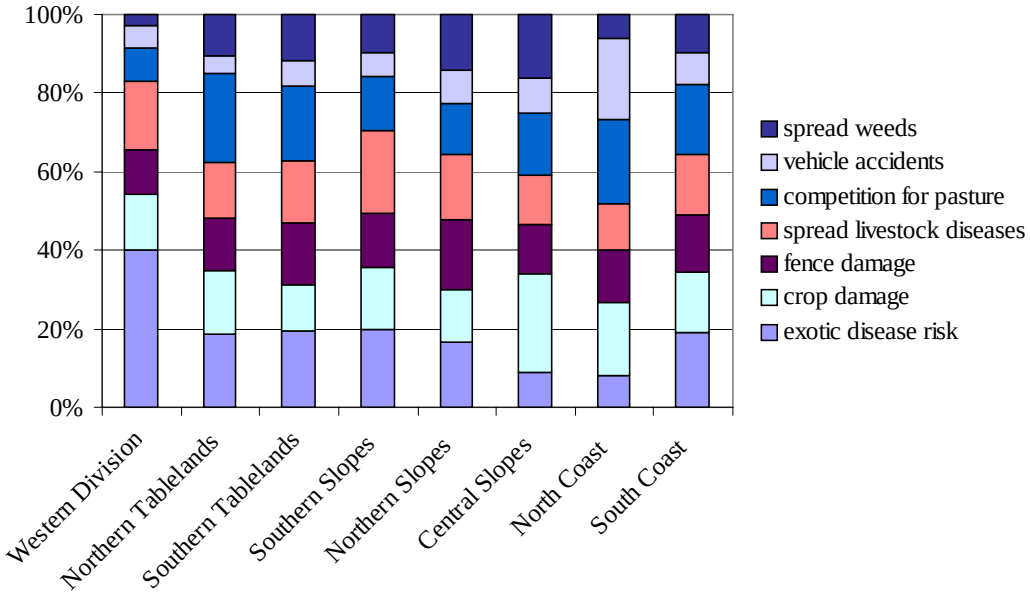

Figure 16. Perceived impacts of wild deer throughout Divisions of NSW during 2004.

Control

There are a limited number of control techniques available for wild deer in NSW. Shooting from the air and from the ground represents the most effective techniques available to reduce the impacts of wild deer. In NSW, ground shooting represented 89.5% of control technique use for wild deer during 2004, representing an increase since 2002 (figure 17). Aerial shooting represents a meagre 4.6% of all techniques implemented (figure 17) despite the suitability of aerial shooting for inaccessible terrain where wild deer often reside. Other techniques used for wild deer control include exclusion fencing (2.8%) and an unspecified technique (possibly repellents) (1.3%). The use of repellents such as sonic devices and spray repellents were reported at very low levels during 2002 (West and Saunders 2003).

Ground shooting was reported as the most commonly used technique in all Divisions of NSW (figure 18). Mustering was generally infrequently used during 2004, and it presents a range of additional animal welfare issues (such as handling and transportation). Mustering of wild deer may provide an immediate income to off-set the costs of control, however the suitability of mustering may in-fact be contingent on specific conditions (similar to those presented for feral goats). Aerial shooting was used mainly in the Western and the Central Slopes Divisions of NSW (possibly synchronised with the control of other pest species) (figure 18). The abundance of wild deer in these Divisions is lower than elsewhere in the State.

Despite reports of recreational deer hunting throughout many regions of NSW (Brian Boyle pers. comm. 2005), hunting per se was reported as a technique used to control wild deer from only one Division of NSW, namely the Northern Tablelands (figure 18). Poor awareness of recreational hunting activities may explain this trend. Recreational hunting (if planned, implemented and regulated very carefully) represents a valuable opportunity for the management of wild deer in NSW. However, caution is required to avoid the possibility of wild deer populations being treated as a sustainable recreational hunting resource.

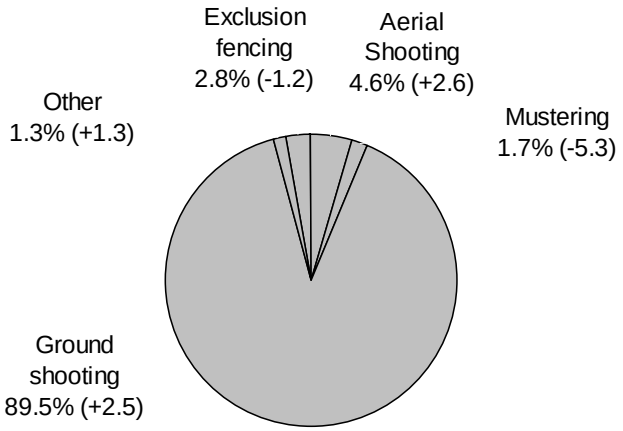

Figure 17. Use of control techniques for wild deer throughout NSW during 2004 (change since 2002).

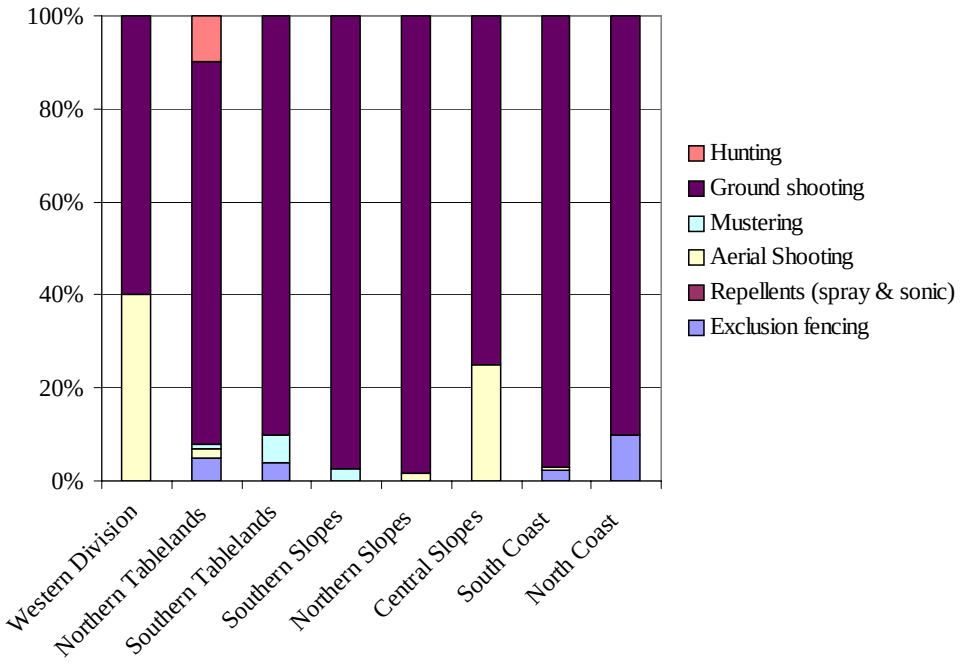

Figure 18. Use of control techniques for wild deer throughout Divisions of NSW during 2004.

Management summary

Wild deer represent an emerging pest animal issue in NSW and Australia. They cause environmental, economic and social impacts, and as such, are classified as a triple-bottom-line impact species. There are 6 species of deer currently living in the wild in NSW and the ACT. The distribution of wild deer encompasses a total area of 48,975km^2 (6%) of the State. At the time of this survey, wild deer had been reported from 30 new locations throughout NSW since 2002, and their distribution had increased by over 8000km^2. This raises serious concern that their range will continue to expand, their impacts increase, and they will become increasingly difficult (and prohibitively costly) to manage. Activities such as the illegal deliberate release and relocation of wild deer are apparently contributing to the expansion of wild deer. Throughout their range, wild deer are mainly at low density within numerous isolated populations, and moderately sized continuous populations stretching from the coastline to the Great Dividing Range. Large continuous populations are a potential risk for the transmission of exotic disease to domestic livestock. If the distribution and abundance of wild deer continues to increase, we should expect a resultant increase in the impacts of wild deer, and possibly the emergence of additional impacts. An increase in the risk wild deer present for the transmission and maintenance of disease is also plausible.

Like many invasive species, once well-established, wild deer may become difficult to control and near impossible to eradicate. Effective management of wild deer hinges on development of suitable control techniques, as well as communication of meaningful information and knowledge about the density, impacts and control of wild deer between authorities responsible for their management. There remains very little known about the movement, dispersal and ranging behaviour of wild deer throughout most regions of the State. There is also an apparent paucity of information about the movement of wild deer during breeding and how movements influence the damage wild deer cause. Similarly, it is unclear whether the seasonality of breeding increases the risk of disease transmission. These issues need to be addressed if long-term management strategies are to be developed for wild deer in NSW and Australia.

4.4 Foxes (*Vulpes vulpes*).


Photo: G Saunders

Foxes were first introduced to Victoria for sport hunting in the 1870's are now widely distributed throughout NSW and Australia. They are a well recognised environmental and agricultural pest, causing significant impacts to native wildlife conservation, and agricultural livestock production. Foxes are opportunistic predators and scavengers and inhabit a wide range of habitats (Saunders *et al*. 1995), including urban/residential areas where resources and shelter are plentiful. Their national distribution largely resembles that of rabbits, and they are often found in low numbers where dingoes are abundant (Saunders *et al*. 1995). Foxes produce an average of four cubs per year during spring. While adults are often very elusive and shy, younger animals are regularly seen during late summer and autumn during a period of sub-adult dispersal. Importantly, foxes may carry and transmit infectious diseases such as rabies. *Predation by foxes* is listed as a *Key Threatening Process* under the *Threatened Species Conservation Act* (1999) and in Australia under the *Environmental Protection and Biodiversity Conservation Act* 1999 (EPBC Act). Foxes are also listed as a declared pest animal under the Rural Lands Protection Act (1998).

Distribution

Foxes are widely distributed throughout NSW, and inhabit all districts of the State. There are few areas that were reported to be fox-free in NSW during 2002, although their local abundance is likely to fluctuate with resource availability, breeding and localised control. Since 2002, fox distribution has remained relatively unchanged: foxes inhabit approximately 98% of the State and they are abundant in all regions of NSW (figure 19, table 8). Foxes were reported as absent from a few isolated areas in eastern and north-eastern NSW (representing 1.4% of the State) (table 8, figure 19). Overall, changes in the density of foxes (mostly small reductions) were reported from 115,000km^2 of the State (appendix 3). However difficulties in estimating fox abundance may have contributed, at least in-part, to these findings. While establishing where foxes are present is usually a relatively simple task (at least where they are common) if animal sign, sightings, impacts, and landholder reports are used, establishing their absence from an area is a more challenging task. This is primarily because foxes are elusive, cryptic, cunning and shy. As a result, caution is required interpreting fox mapping information presented herein.

Impacts

Foxes cause a wide range of impacts to the environment, the economy and society. Foxes account for the highest triple-bottom-line impacts of any species in Australia according to recent estimates (McLeod 2004). They are effective predators of native wildlife, prey on newborn lambs, and are scavengers of refuse around townships and cities. While many of the

direct impacts of foxes remain largely unquantified, there are also many additional costs associated with their management. The cost of controlling foxes is also considerable. Up to $16 million is spent annually on control campaigns around Australia (McLeod 2004).

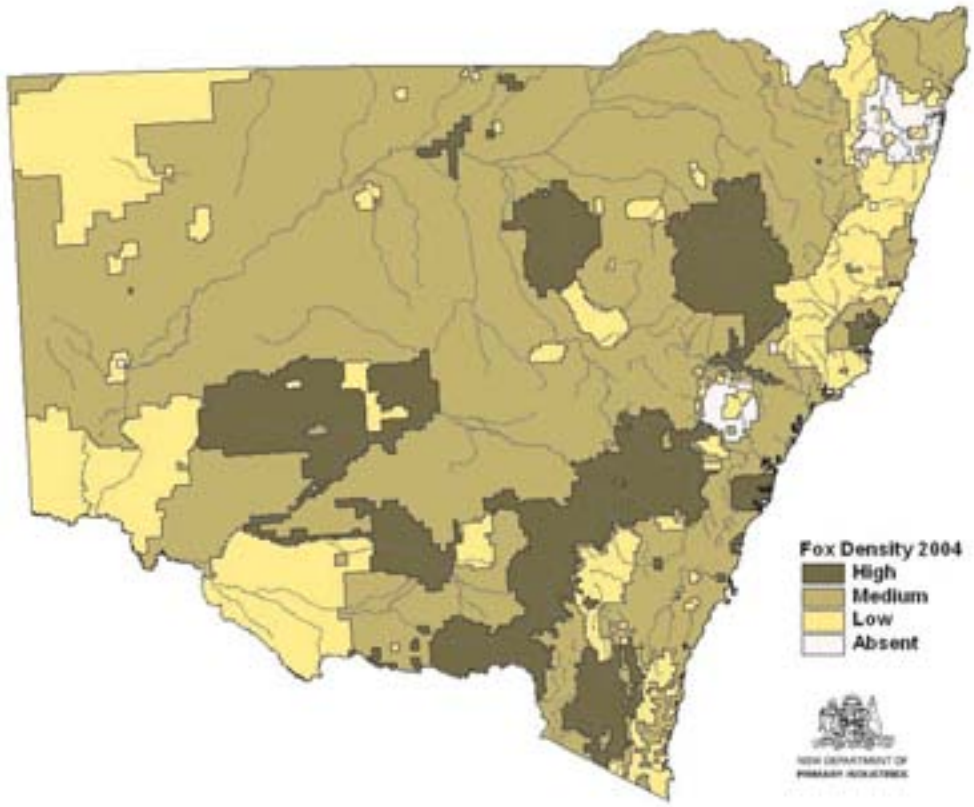

Figure 19. Density of foxes throughout NSW and the ACT during 2004.

Table 8. Area inhabited by foxes throughout NSW (km^2) (with percentage areas in brackets).

	Density km^2 (percent of NSW)				
Year	**High**	**Medium**	**Low**	**Absent**	**Total occupied**
2004	134 529 (16.4)	516 790 (63)	157 478 (19.2)	11 484 (1.4)	808 818 (98.6)
2002[1]	172 419 (21)	541 601 (66)	90 189 (11)	16 093 (2)	804 210 (98)

[1] West and Saunders (2003)

Impacts

Foxes cause a wide range of impacts to the environment, the economy and society. They account for the highest triple-bottom-line impacts of any species in Australia according to recent estimates (McLeod 2004). They are effective predators of native wildlife, displace native predators, prey on newborn lambs, and are scavengers of refuse around townships and cities. While many of the direct impacts of foxes remain largely unquantified, there are many additional costs associated with their management, such as the costs of control. Up to $16 million is spent annually on fox control campaigns around Australia (McLeod 2004).

In NSW during 2004, fox impacts on lamb production and native wildlife were most significant, followed by exotic disease risk, other livestock predation, spread of weeds and livestock disease (figure 20) This trend was consistent with the findings in 2002 (West and

Saunders 2003). There were no major differences in the impacts observed between 2002 and 2004, however lamb predation was marginally higher in 2004. This may have been a result of a widespread reduction in livestock farming activities throughout drought afflicted areas of the State, and losses by foxes becoming more apparent to landholders.

There were some observed differences in reported impacts attributed to foxes throughout NSW. Lamb predation was significantly lower in the North Coast Region than elsewhere in the State (figure 21), possibly associated with cattle grazing in these regions. Differences were observed in the spread of weeds by foxes, and the spread of livestock disease throughout the divisions of NSW (figure 21). In contrast, predation of wildlife was seemingly equal in all divisions, and there were similarities in perceived levels of impact for exotic disease risk, and other livestock predation (figure 21). These trends may be realistic given large variation throughout NSW in livestock practices, levels of fox control, management activities, available prey, and alternative resources such as refuse, rubbish tips and scavenging opportunities.

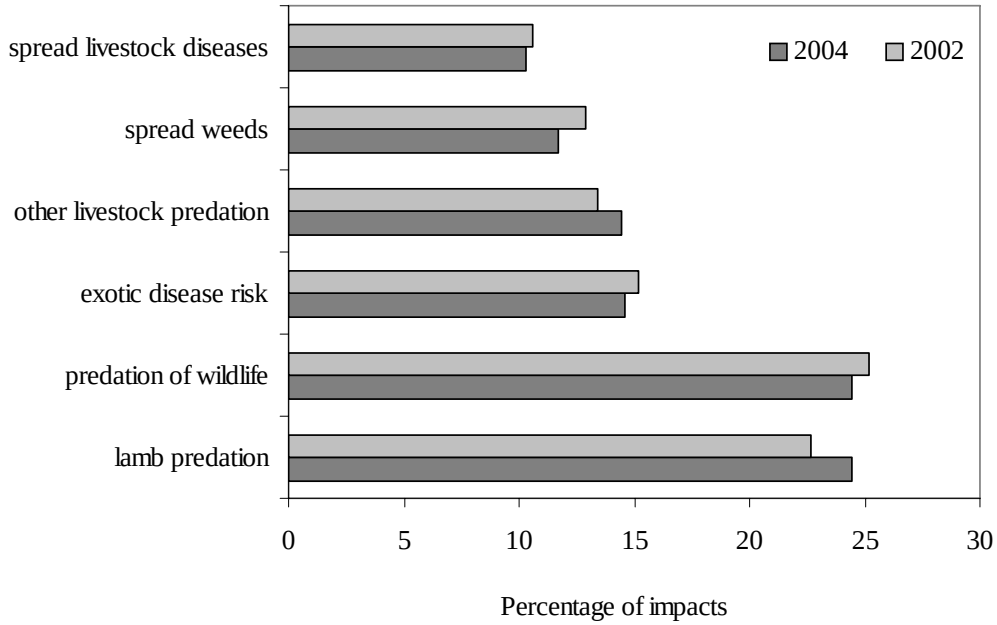

Figure 20. Perceived impacts of foxes throughout NSW during 2004.

Control

There are many techniques available for fox control in Australia, however the most commonly used techniques involve poisoning or shooting of animals. In NSW, there were 8 control techniques used throughout the agricultural zones during 2004 (figure 23). Poison baiting (with 1080) represented the most widely used technique (76.7%), followed by ground shooting (13%) (Figure 22). Other techniques included trapping, exclusion fencing, den fumigation, fox drives, use of guard animals, and other (non-descript) techniques (figure 22). In comparison to 2002, there were few changes in control techniques use. The States' drought assistance program in western NSW almost exclusively involved provision of poison baits to landholders, perhaps explaining the marginal increase in baiting throughout the State. Poison baiting with 1080 represents the primary control technique being used throughout NSW (figure 22 and 23). There were no Divisions of NSW where poison baiting represented the only technique used, however other techniques rarely represented more than 18% of overall technique use (figure 23). Ground shooting was the second-most commonly used technique (figure 22), being used in all Divisions (figure 23).

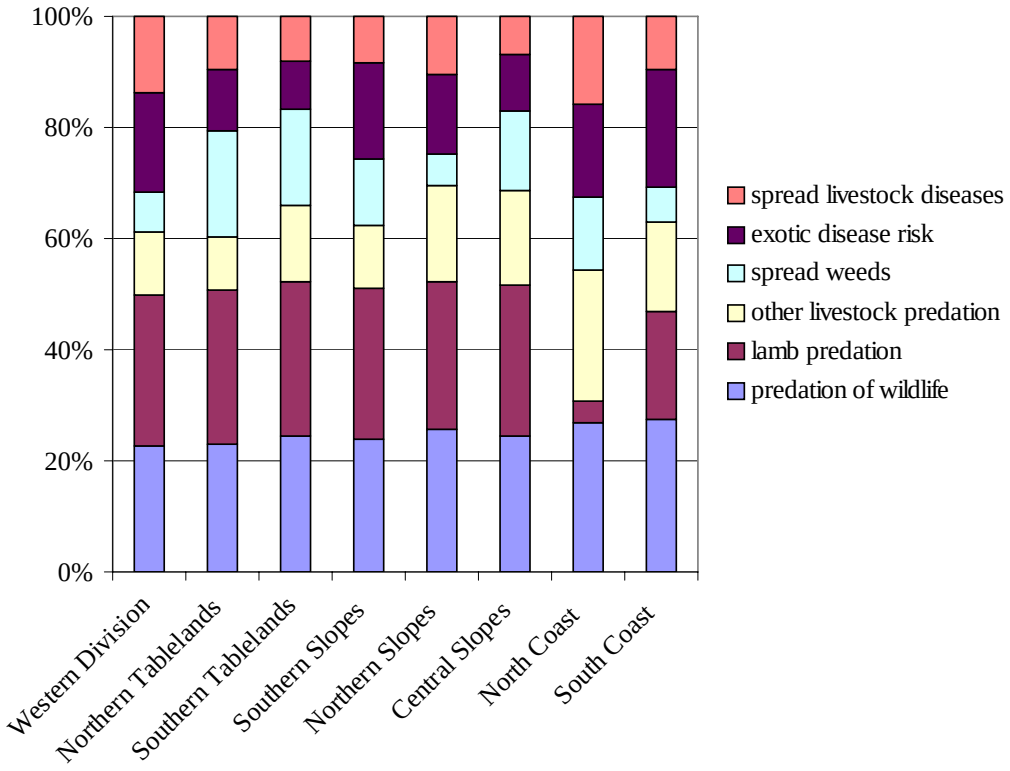

Figure 21. Perceived impacts of foxes throughout Divisions of NSW during 2004.

The use of guard animals (dogs and llama/alpacas) to protect livestock has increased in popularity in recent years. Although guard animals constituted a small proportion of overall control technique use (figure 22), and were perceived to be an effective control technique in many Districts of the State (table 9), many others reported uncertainty about their effectiveness (table 9). Importantly, only a small number of Districts reported guard animals as being ineffective to protect livestock (table 9).

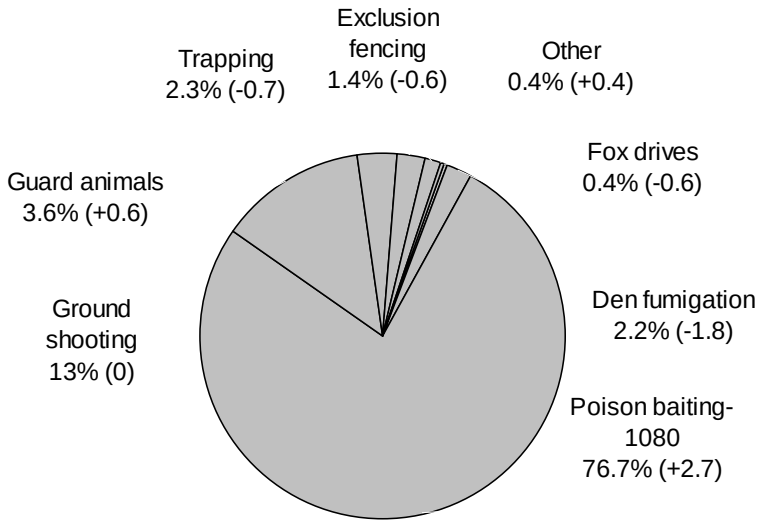

Figure 22. Use of control techniques for foxes throughout NSW during 2004 (change since 2002).

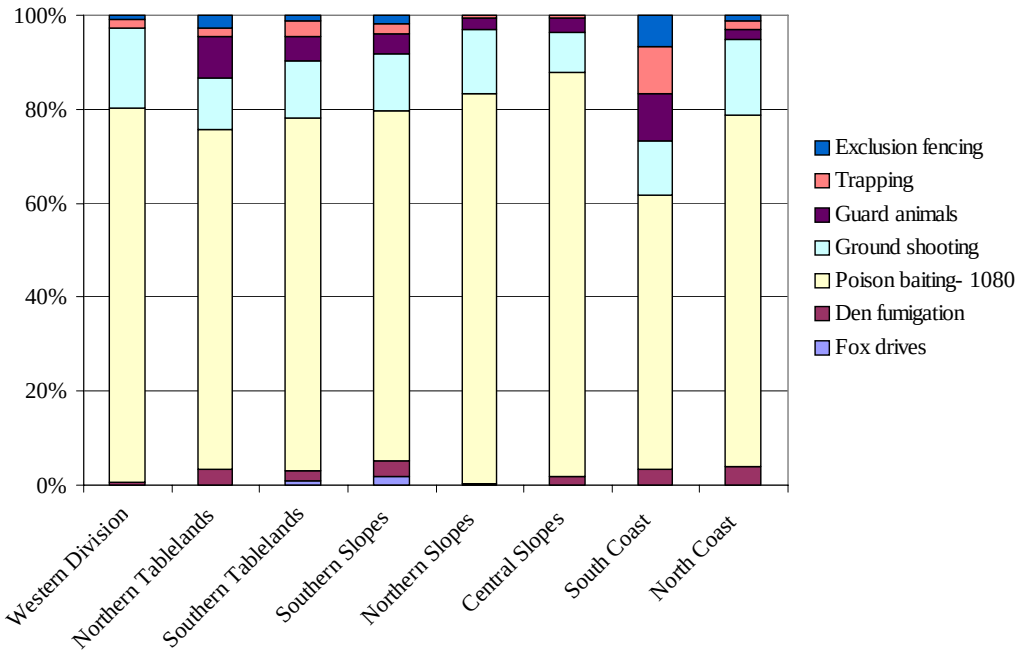

Figure 23. Use of control techniques for foxes throughout Divisions of NSW during 2004.

Table 9. Perceived effectiveness of dogs, and llamas/alpacas as guard animals for foxes in the RLPB Districts of NSW during 2004.

	Number of RLPB Districts
Dogs were effective guard animals	13
Dogs were ineffective guard animals	6
Unclear whether dogs were effective or ineffective	18
Dogs were not used as guards animals	11
Llamas / alpacas were effective guard animals	11
Llamas / alpacas were ineffective guard animals	7
Unclear whether llamas and alpacas were effective or ineffective	18
Llamas / alpacas were not used as guards animals	12

Management Summary

Foxes remain widespread throughout NSW despite recent drought conditions and increased levels of control (at least throughout the Western Division of NSW). There were several large areas reported to have experienced reductions in fox abundance, probably linked with increased control effort (appendix 3). Reductions observed in several eastern regions were also likely to be associated with increased landholder coordination, stimulated through such programs as ‘outfox-the-fox’. Without adequate follow-up control in these regions, the net-benefits gained from reduced abundance are likely to be short-lived. As a result, we recommend continued attention and strategic planning of fox control in these areas to maximise the long-term net-benefits from reduced abundance. While poison baiting can be an effective control technique, integration with a range of additional techniques is likely to provide the greatest rewards. Alternative techniques, such as guard animals should be considered, and requires widespread trial/application. Best practice management is encouraged to reduce the impacts of foxes, by coordinating control across large areas, involving multiple landholders, and applying a range of techniques simultaneously. Follow-up control is also essential to lessen population recovery.

4.5 Rabbits (*Oryctolagus cuniculus*).


Photo CSIRO

Rabbits were introduced to mainland Australian in 1858 from England (Myers 1995). The distribution of wild rabbits in Australia now encompasses all States and Territories. They inhabit dry arid and semi-arid landscapes through to alpine tundra (Williams *et al*. 1995). Historically, rabbits have been considered an agricultural pest mainly to graziers because they compete with livestock for pasture. Rabbits are also a major environmental pest as they compete with native grazing animals, cause damage to native vegetation communities, cause and accelerate soil erosion, and are implicated in long term land degradation (Williams *et al*. 1995). Rabbit populations generally fluctuate in response to rainfall and pasture availability. During drought conditions when pasture availability is very low, rabbit populations are usually reduced in size. However, they can quickly respond when conditions become more favourable, as females can breed very early, and produce between 15 – 40 young per year. Rabbits are a significant introduced herbivore in NSW, and are a declared pest animal under the Rural Lands Protection Act (1998), and *Competition and grazing by rabbits* has been listed as a Key Threatening Process under the *NSW Threatened Species Conservation Act* (1995).

Distribution

In NSW, rabbits are widely distributed throughout all Districts (figure 24). Most of NSW is characterised by widespread low density populations combined with numerous fragmented medium – high density populations (particularly in the north-east and south west Districts). In some regional areas, rabbits were also reported as being absent, possibly associated with unfavourable soil conditions or moisture availability (figure 24).

Since 2002, rabbits have slightly increased their total range throughout NSW, and currently occupy approximately 569 000km^2 (70.9%) of the State (table 10). This trend is consistent with a gradual recovery of rabbits throughout Australia following the widespread release of rabbit calicivirus disease a decade ago. Conversely, the total area reported as containing high and medium density populations has declined, while areas reported as low has increased, suggesting a decline in abundance. Widespread drought conditions may have caused this perceived trend. Changes in the abundance of rabbits were reported from over 45,000km^2 of the State, mainly located in the eastern and central Divisions (appendix 3). Several Districts, and many small fragmented areas were reported to have experienced slight increases in rabbit abundance. However, there were also numerous regions where the abundance of rabbits had been reduced, possibly associated with successful local-scale control programs or by widespread drought (appendix 3). The affects of drought have been known to cause a sizable reduction in localised rabbit populations, rabbits are particularly resistant to dry conditions,

obtaining most moisture needs from the plants they graze/browse. This reduces reliance on the availability of standing water, that is often a limiting factor for other pests species in Australia.

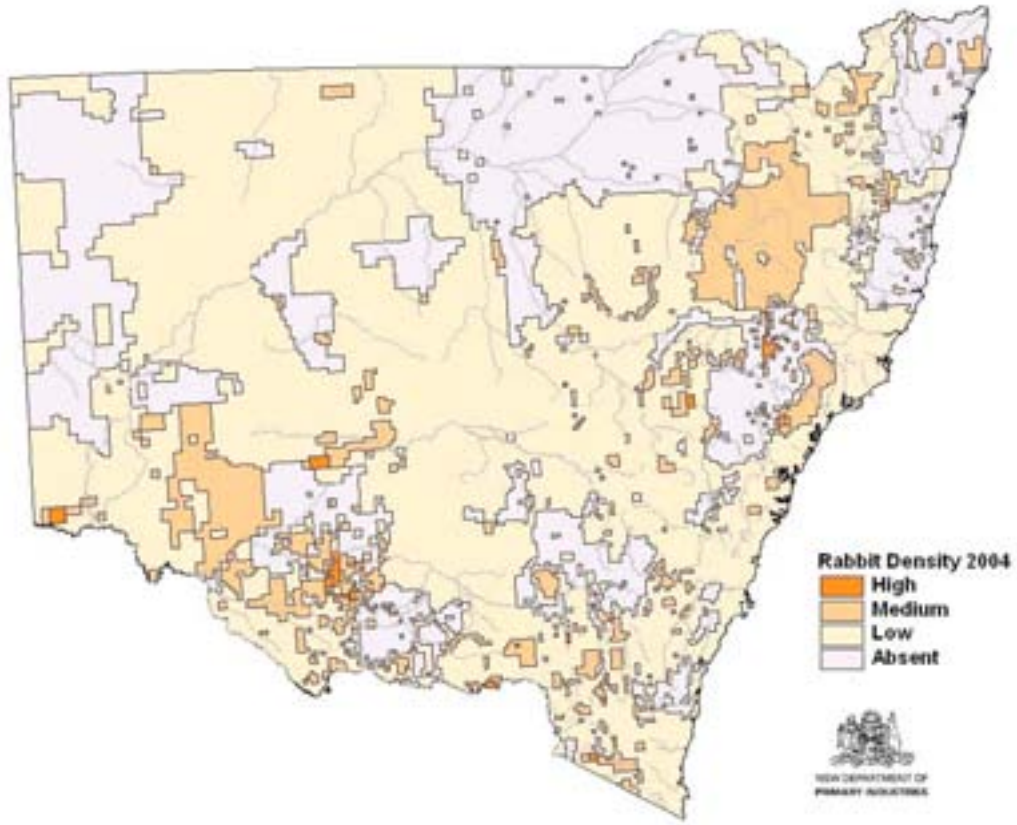

Figure 24. Density of rabbits throughout NSW and the ACT during 2004.

Table 10. Area inhabited by rabbits throughout NSW (km^2) (with percentage areas in brackets).

Year	Density km^2 (percent of NSW)				
	High	**Medium**	**Low**	**Absent**	**Total occupied**
2004	3 113 (0.4)	78 052 (9.7)	488 737 (60.8)	234 095 (29.1)	569 902 (70.9)
2002[1]	4 643 (< 1)	91 375 (11)	471 423 (58)	252 142 (31)	563 261 (69)

[1] West and Saunders (2003)

Impacts

According to the survey participants, the highest impacts of rabbits in NSW during 2004 were competition for pasture, followed by soil erosion and land degradation, and prevention of native vegetation regeneration (figure 25). Other impacts were competition with native wildlife (primarily for food), spread of weeds (or causing disturbance supporting weed colonisation), and exotic disease threat (figure 25). These findings were relatively unchanged from the survey outcomes of 2002 (West and Saunders 2003). However, small increases were reported for completion for pasture, and competition with native wildlife, possibly associated with drought conditions prevailing throughout much of NSW.

The impacts of rabbits were similar throughout the Divisions of NSW (figure 26). Minor differences were noted for the spread of weeds, and for the prevention of native vegetation regeneration (figure 26). Somewhat uniform levels of impact for rabbits across Divisions is possibly associated with three features regarding rabbit populations: rabbits are widespread in NSW; rabbits inhabit a wide range of habitat types; and their impacts are broad-ranging (e.g. rabbits may be perceived as competing for pasture regardless of pasture availability).

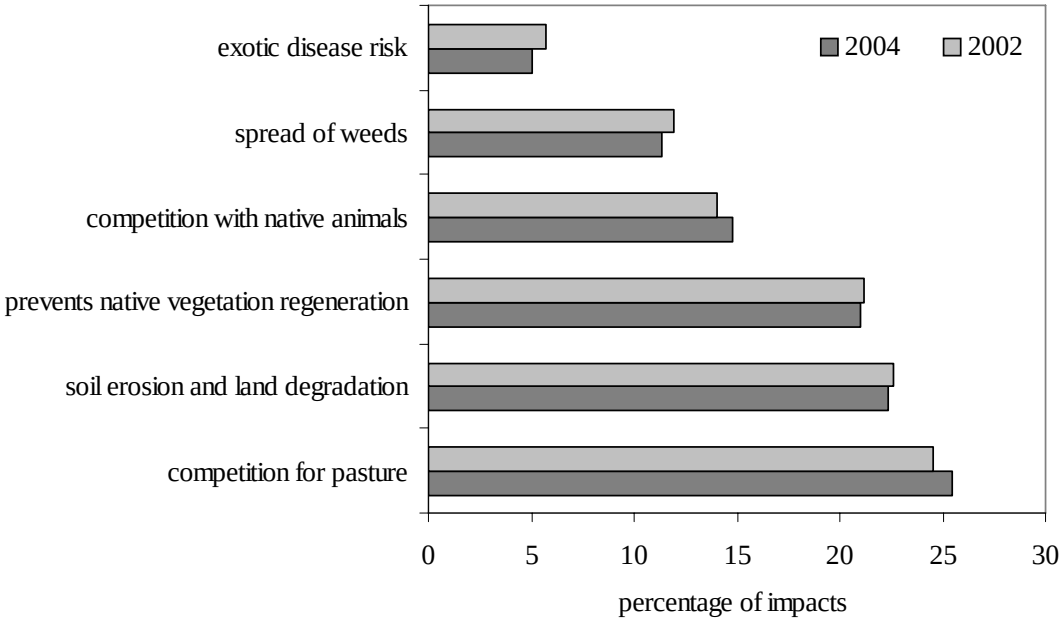

Figure 25. Perceived impacts of rabbits throughout NSW during 2002 and 2004.

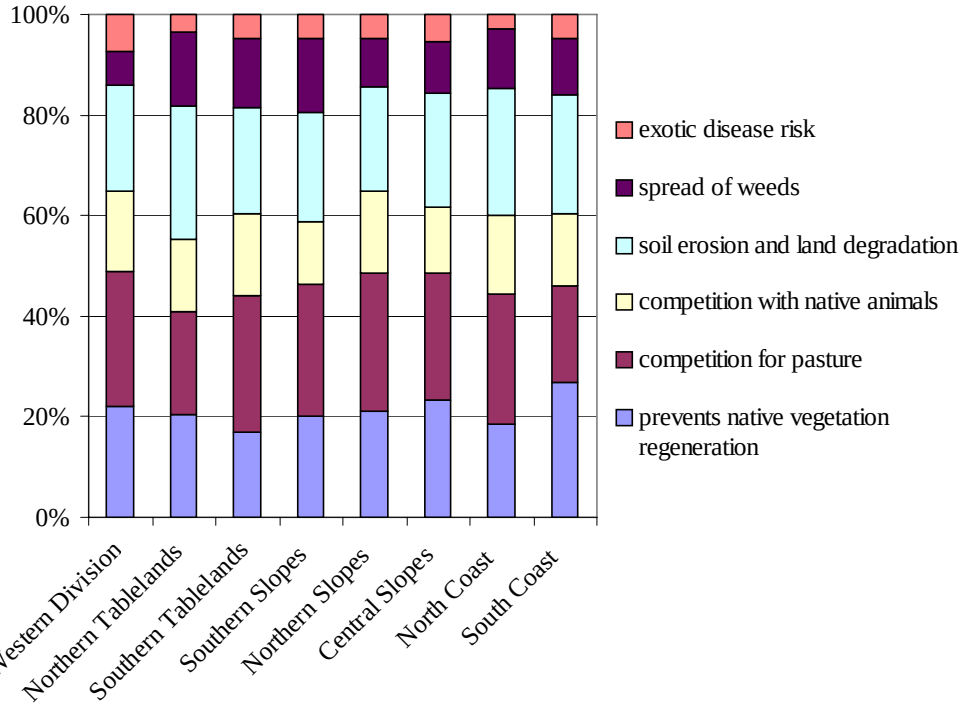

Figure 26. Perceived impacts of rabbits throughout Divisions of NSW during 2004.

Control

There are a large number of well-tested techniques available to control rabbits and their impacts in Australia. In NSW during 2004, there were 13 control techniques used (often in combination) throughout the agricultural regions of the State. Poison baiting (with 1080) (23.9%) represented the most commonly used technique, followed by biological control with RCD (19%), and poison baiting (with Pindone) (14.1%) (figure 27). Although the use of RCD was ranked high (and had increased since 2002 by 10%)(figure 27), anecdotal evidence suggests this finding most likely reflects the perception that existing virus within rabbit populations was contributing to the control of rabbits in combination with occasional direct release of virus during 2004. In other words, both direct release and existing virus in populations was perceived as equating to 19% of total control. The use of most other techniques was comparable to the estimates presented in 2002 suggesting the management of rabbit populations had changed very little between survey periods.

Not surprisingly, the use of techniques varied substantially throughout the Divisions of NSW (figure 28). For example, RCD varied from 5% – 44% between Northern Tablelands and the South Coast Divisions respectively (figure 28). Similarly, the use of poison baiting with 1080 ranged from 3% – 50 % between South Coast and Central Slopes Divisions respectively. With the exception of trapping, exclusion fencing, blasting and commercial/recreational harvesting that were undertaken very infrequently throughout NSW, almost all other techniques were used at quite different levels throughout the Divisions of NSW (figure 28). This may be associated with the high variability of landscapes inhabited by rabbits ranging from town cemeteries, temperate forests, to open sand dunes in western NSW. Variation in the use of control methods may also relate to the variable costs of control, experience and skills of landholders/operators, personal preference, availability of control equipment, and the suitability of each technique for different environments.

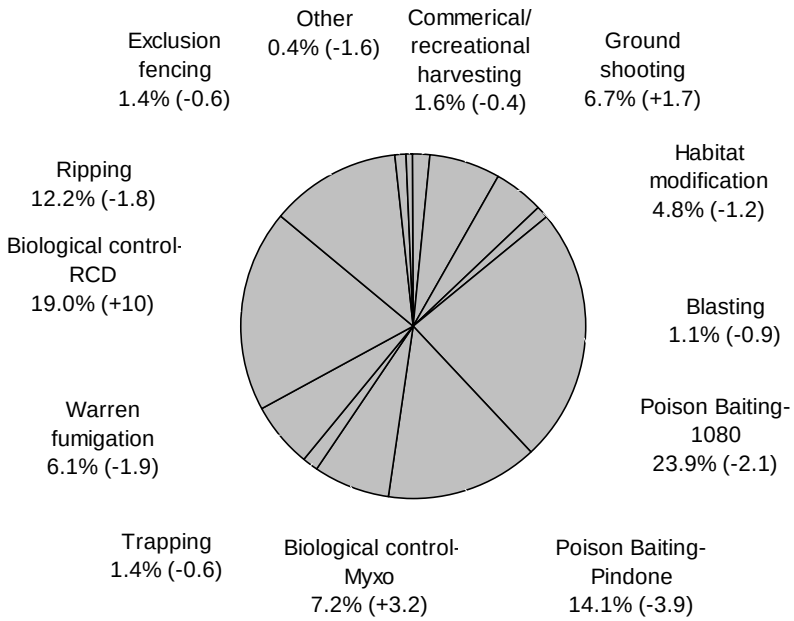

Figure 27. Use of control techniques for rabbits throughout NSW during 2004 (change since 2002).

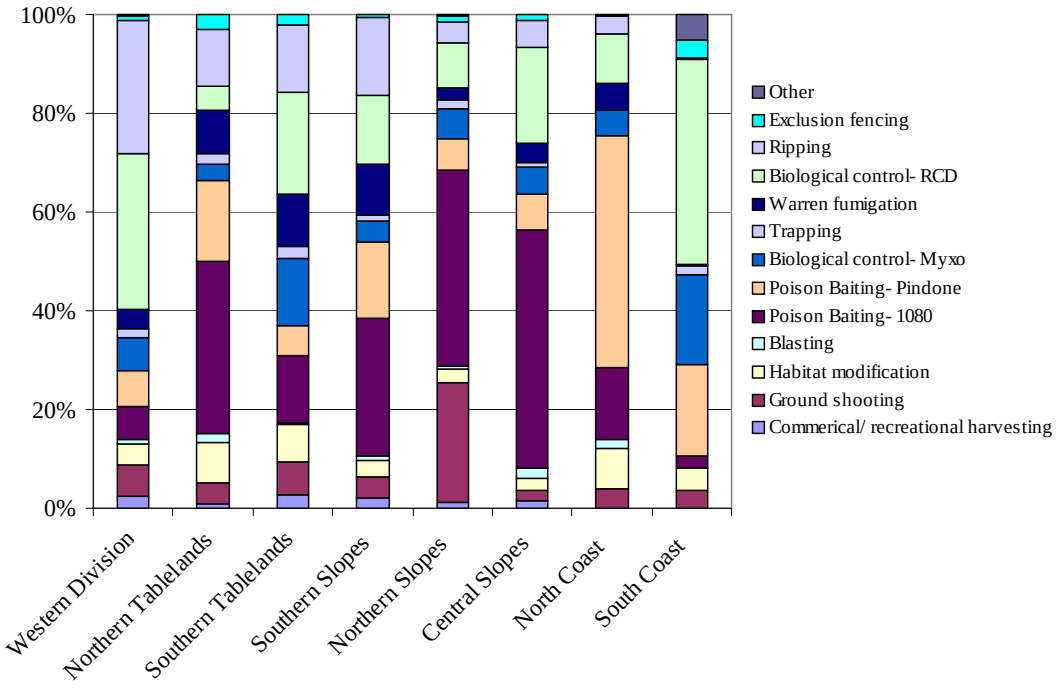

Figure 28. Use of control techniques for rabbits throughout Divisions of NSW during 2004.

Management Summary

Rabbits remain widely distributed throughout NSW mainly at densities classified as 'low'. Their distribution has increased slightly since 2002, and is characterised by numerous small fragmented/clumped populations, consistent with the findings of many other studies throughout Australia (Williams *et al*. 1995). The recent widespread drought in NSW has apparently had limited affect on the distribution of rabbits, but may have caused declines in the abundance of rabbits throughout many regions of the State (appendix 3). This implies that rabbit distribution alone is not a good measure of population response to drought or control activities. Reluctance or an inability by landholders to control rabbits during drought, may have contributed to increases in abundance in some areas (appendix 3). To maximise the success of any natural population reductions associated with the drought, follow-up control is recommended to lessen/slow possible population recovery.

The impacts of rabbits have remained relatively consistent with the survey conducted during 2002, suggesting little has changed regarding their management over the same period. The techniques used to control rabbits are dominated by chemical control (through poison baiting with 1080 and pindone), biological control (RCD and myxomatosis) and mechanical control (warren ripping) representing 76.4% of all techniques used. Control programs should utilise a range of techniques to control rabbits, in collaborative programs engaging many landholders. An integrated approach is most likely to produce cost-effective control outcomes.

4.6 Dingoes and wild dogs (*Canis lupus* sp.)


Photo P Fleming

Dingoes and wild dogs in Australia are descendents of domesticated European dogs and are considered pest animals primarily where they are responsible for predation and injury of livestock (particularly sheep), and where they pose risk to humans. Wild dogs are a declared pest species in NSW under the Rural Lands Protection Act (1998). They are also considered a native animal by many Australian's, and an icon species of wild places. Not-surprisingly, their management is controversial because of conflict between pest control legislation and conservation policies. However, the survival of dingoes in the wild is contingent on achieving a delicate balance between conservation and livestock protection practices.

Dingoes and wild dogs occupy a wide range of habitats in NSW. Previous surveys have indicated that they are found between the mountains of the Great Dividing Range and the coastal fringe, throughout the tablelands regions and in far-western NSW (West and Saunders 2003). Females usually produce a litter of about five pups during winter months, however litters from feral domestic dogs and hybrids are usually produced in summer and autumn (Fleming *et al*. 2001). The role of dingoes and other wild dogs in the environment, including how dingoes interact with foxes, feral cats and native predators is not well understood. As a top-order predator, it is likely that dingoes perform a valuable environmental service, limiting the abundance of herbivores (such as the Eastern Grey Kangaroo, *Macropus giganteus*) in many areas.

Distribution

Dingoes and wild dogs can be found in the north coast, south coast, southern tablelands, and far western Divisions of NSW (figure 29). Their distribution is largely concentrated throughout the northern and southern coastal Divisions (between the mountains and coast), throughout the pastoral zone of the northern and southern tablelands, and within the semi-arid woodlands and shrublands of far-western NSW (figure 29). Their distribution is also characterised be many fragmented populations throughout the northern slopes, northern tablelands, and southern tablelands (figure 29). Since 2002, their overall distribution has increased marginally from 28% to 30% of the State, and increased across all three density classes (table 11). They were reported as occurring at low density over half of their range, at medium densities throughout one-third of their range, and at high densities in just over 10% of their range (table 11).

According to the survey participants, there were many areas where an increase in dingoes and wild dog density was reported throughout NSW between 2002 and 2004/05 (appendix 3). Increases were reported from many small/medium-sized areas throughout most Divisions of their range, in particular, the southern tablelands, and far-western Divisions (appendix 3).

There were also several small areas that reputedly experienced large increases, including the Hunter region between north and south coast Divisions (appendix 3). These increases may have resulted from an inability of many landholders to undertake control during the recent drought period. A number of decreases were also reported from areas throughout the southern tablelands and south coast Divisions (appendix 3). These decreases may have been associated with localised control programs, or a culmination of drought and control as decreases were reported from many regions afflicted by drought in recent years. Wild dogs/ dingoes are absent from 70% of NSW. Dingoes and wild dogs are also mobile species with the capacity to range long distances. This aspect needs to be considered when interpreting changes in their distribution and abundance, and in their management throughout NSW.

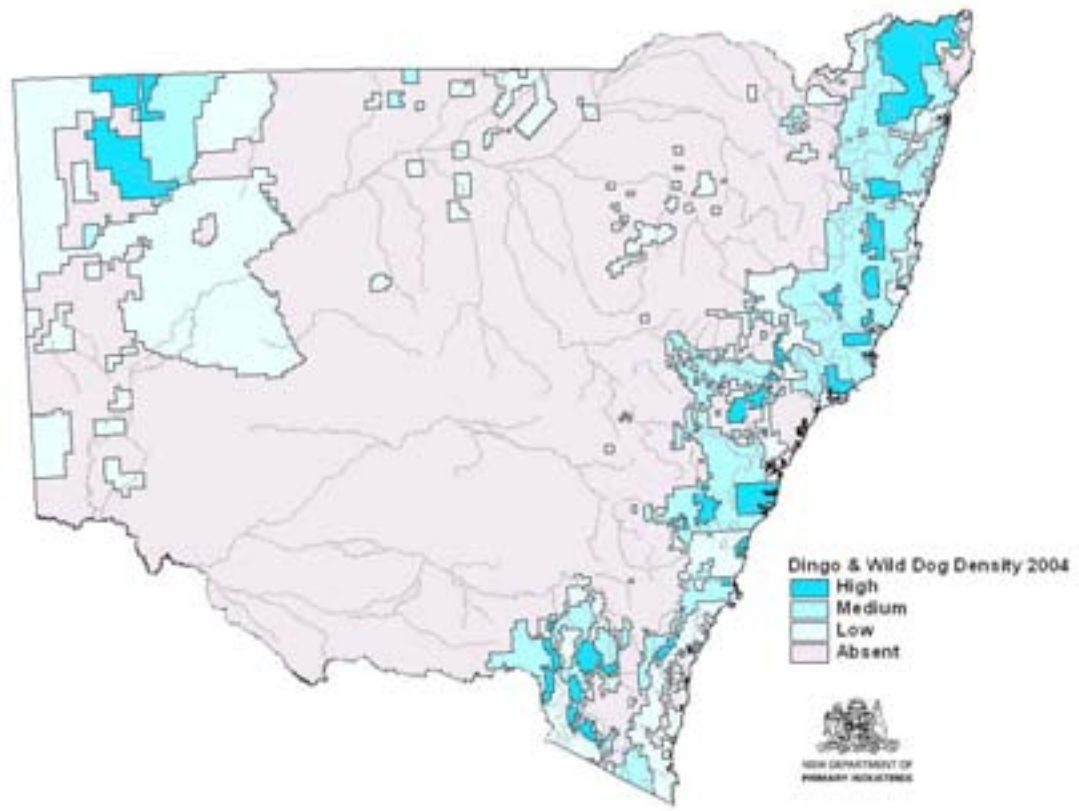

Figure 29. Density of Dingoes and other Wild Dogs throughout NSW and the ACT during 2004.

Table 11. Area inhabited by dingoes and other wild dogs throughout NSW (km^2) (with percentage areas in brackets).

Year	**Density km^2 (percent of NSW)**				
	High	**Medium**	**Low**	**Absent**	**Total occupied**
2004	29 561 (3.7)	80 149 (10)	130 967 (16.3)	563 325 (70)	240 677 (30)
2002[1]	25 595 (3)	78 459 (9)	128 671 (16)	585 881 (72)	232 727 (28)

[1] West and Saunders (2003)

Impacts

Dingoes and wild dogs are known to cause a number of impacts throughout Australia, in particular to native wildlife and domestic livestock production. Although estimates of adverse impacts through predation of livestock are difficult to quantify, McLeod (2004) estimated an annual economic loss (and costs associated with wild dog control) at $66 million. In NSW, predation of livestock and predation of wildlife are the two highest ranked impacts of dingoes and wild dogs (figure 30). Dingoes and wild dogs are also perceived as a disease risk to some (figure 30), possibly attributed to a long history of feral dogs carrying rabies throughout many regions of the world. According to the survey participants, the overall rating for predation or livestock, predation of wildlife, spread of livestock disease and killing of farm dogs increased slightly between 2002 and 2004/05, although these differences were not substantial (figure 30).

The impacts of dingoes and wild dogs were relatively uniform across most Divisions of NSW, with the exception of the Central Slopes where predation of livestock was significantly higher (figure 31). As dingoes and wild dogs were not reported from many areas within the Central Slopes Division (figure 29), caution is required interpreting this information. Consistently high levels of predation of livestock were reported throughout all Divisions suggest that their perceived impacts are uniform irrespective of habitat, land tenure and agricultural practices. In reality, this may not be the case, as the impacts of dingoes and wild dogs on livestock production are more pronounced in certain agricultural zones of the State (Fleming pers. comm. 2006).

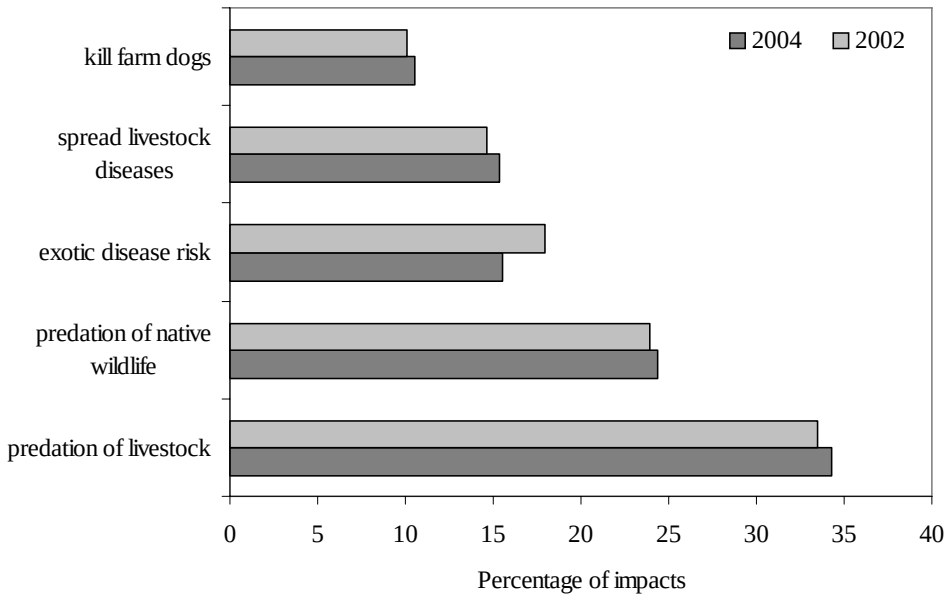

Figure 30. Perceived impacts of dingoes and wild dogs throughout NSW during 2002 and 2004.

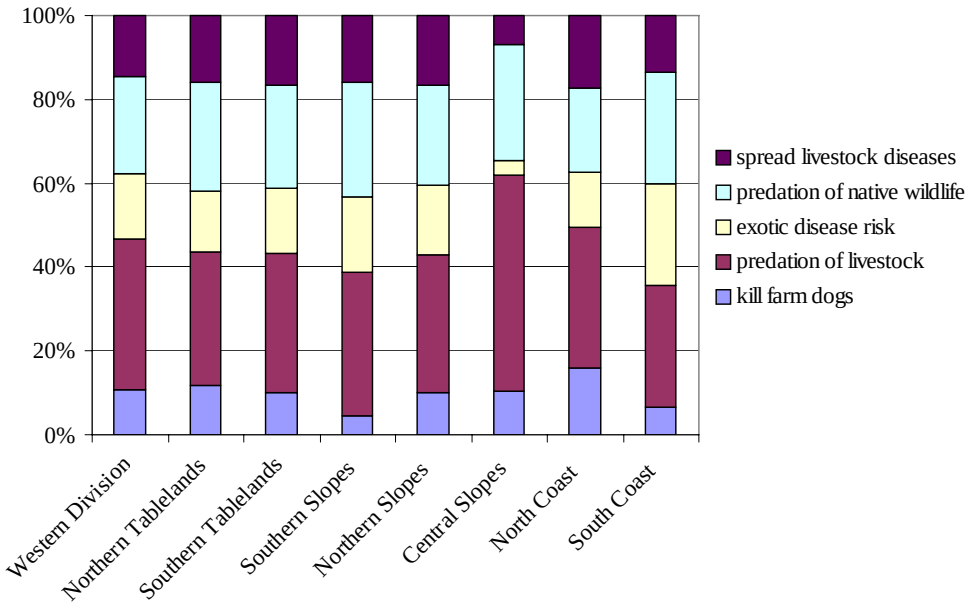

Figure 31. Perceived impacts of dingoes and wild dogs throughout Divisions of NSW during 2004.

Control

There are a number of techniques available to control dingoes and wild dogs in Australia. In NSW, ground baiting (with 1080) was the most commonly used technique (52.1%) (figure 32) consistent across all Divisions of the State (figure 33), followed by ground shooting (15.1%) and trapping (13.1%). Other techniques include dog drives, guard animals, exclusion fencing, aerial baiting and non-descript techniques (figure 32). Overall, the use of specified techniques in NSW has not changed substantially since 2002 (figure 32). However, within NSW the use of techniques varies enormously (figure 33), and this is likely to be a result of differences in the suitability of techniques across the range of environments that dingoes and wild dogs inhabit. Other possible explanations for this trend include variation in resources, skills, and accessibility to the areas inhabited by dingoes and wild dogs. Some NSW Divisions rely almost exclusively on a few techniques to control dingoes and wild dogs, such as Districts within the Central Slopes Division. Other Divisions utilise a wide range of techniques, such as the Northern Tablelands and Northern Slopes. It is highly recommended that a range of techniques are used simultaneously to address the problems caused by dingoes and wild dogs, to maximise the effectiveness of control programs. An integrated approach combined with a collaborative program between many landholders is most likely to produce costs-effective outcomes from any future control initiatives.

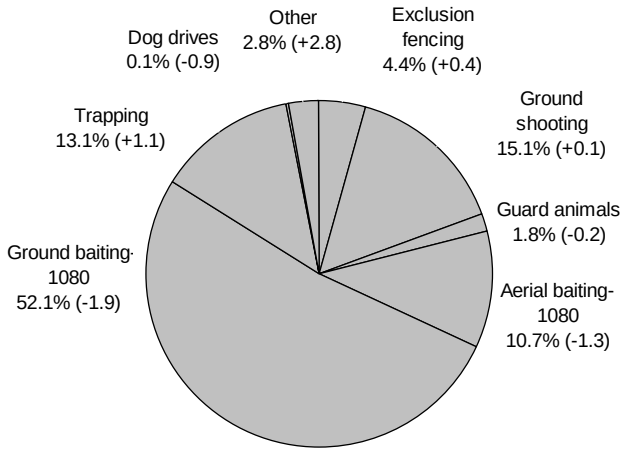

Figure 32. Use of control techniques for dingoes and wild dogs throughout NSW during 2004.

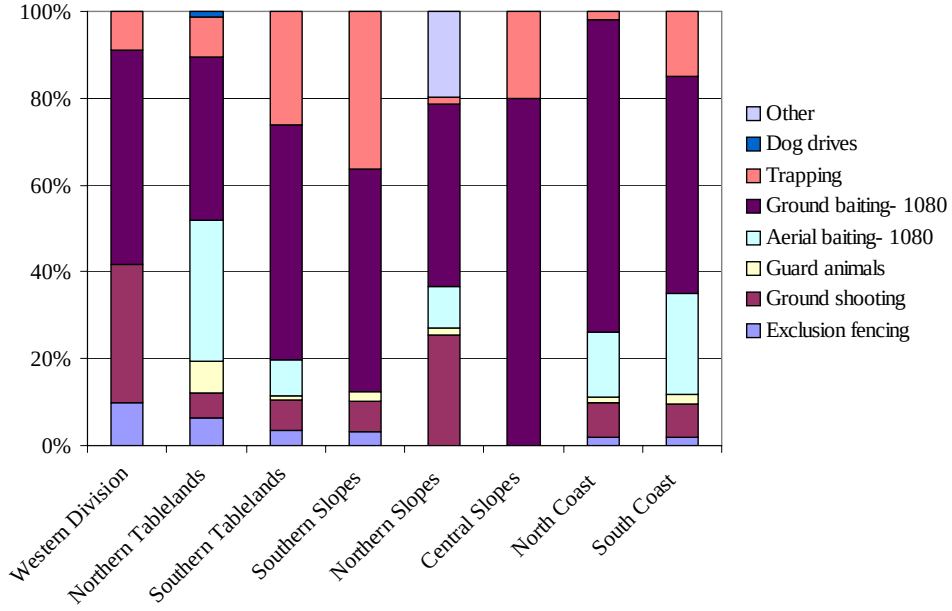

Figure 33. Use of control techniques for dingoes and wild dogs throughout Divisions of NSW during 2004.

Management summary

Dingoes and wild dogs inhabit approximately one-third of NSW, mainly at low densities. Their State distribution is characterised by fragmented populations throughout many Divisions. Their distribution has slightly increased since the survey conducted during 2002, and there have been increases in the proportion of their range classified as high, medium and low densities respectively. These changes may have resulted from an inability to control dingoes and wild dogs during recent drought. Their impacts have not changed substantially from the previous survey; predation of livestock, and predation of wildlife rated highest throughout all Divisions of the State. The main techniques to control dingoes and wild dogs include ground baiting (with 1080), ground shooting and trapping. There was also considerable variation in the use of techniques throughout the Divisions of NSW, despite previous initiatives to encourage the use of multiple techniques to maximise the effectiveness of broad-scale control programs.

4.7 Feral cats (*Felis catus*)


Photo M Davis

Domestic cats were introduced to Australia either prior to or during European settlement, and have been deliberately released in many areas to control rabbits, mice and rats (McLeod 2004). By the mid 1800's, feral cat populations had become well-established in the wild, and today feral cats can be found in almost every significant habitat type throughout mainland Australia and on many offshore islands. Feral cats inhabit sub-alpine areas, sandy deserts, forests and coastal dune systems. They also inhabit modified landscape, urban residential areas and industrial estates. Feral cats are highly efficient predators and are responsible for predation of a wide range of native species. For this reason, *predation by feral cats* has been listed as a Key Threatening Process in NSW under the Threatened Species Conservation Act (1995) and the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). They prey on native small mammals (up to the size of a brush-tailed possum), birds, reptiles, amphibians, fish and insects (Dickman 1996). Feral cats also prey on young rabbits and have been used to control mice and rat numbers (Rolls 1984). Because feral cats gain moisture from their prey, they can survive in very dry landscapes. They generally breed in any season and at a very young age, allowing populations to respond quickly to changes in available resources. Unlike many introduced species, constant dispersal/supply of dumped and stray domestic animals from urban areas is suspected of replenishing feral populations. Feral cats are also a risk to humans, as they can carry and transmit Toxoplasmosis.

Distribution

In Australia, feral cats occur in every State and Territory. In NSW, feral cats occur in all regions/Districts and inhabit 93% of the State (figure 34, table 12). Throughout most of their range, feral cats are consistently reported as occurring at low densities (figure 34, table 12) interspersed with numerous localised higher abundance areas commonly associated with cities/ towns, major waterways and outlying waste disposal/rubbish tips. According to survey participants, feral cats are less abundant (or less commonly observed) further from settled areas/townships. A number of areas were reported as containing no feral cats, possibly associated with high numbers of other large predators (e.g. foxes, dingoes and wild dogs), or possibly associated with control activities for other species. While the abundance of feral cats has been reported as low throughout most of western NSW, anecdotal evidence suggests many areas in this region contain very few if any feral cats. However, without rigorous field surveys and sampling, it was not possible to verify if areas marked as 'absent' were realistic. Feral cats are notoriously difficult to locate and particularly difficult to map. For these reasons, combined with their highly mobile, elusive and cryptic behaviour, caution is required interpreting the abundance information presented for NSW. However, wherever feral cat abundance has been measured using field sampling techniques, such as sand pads as part of regional monitoring programs, information from these initiatives has been included in the current survey.

Because of significant variation in the detection of feral cats between different habitat types (as visibility is largely influenced by vegetation cover), numbers in grassland environments may be perceived as higher than in forests and closed woodlands, where they may be rarely seen. These observational differences need to be considered when interpreting figure 34. Anecdotal evidence also suggests feral cat numbers fluctuate in the western regions of the State more drastically than in higher rainfall regions where prey resources are more stable. No previous information is available to assess change in feral cat distribution and abundance. It is hoped information contained in this survey can form the basis of future assessments of feral cat distribution and abundance.

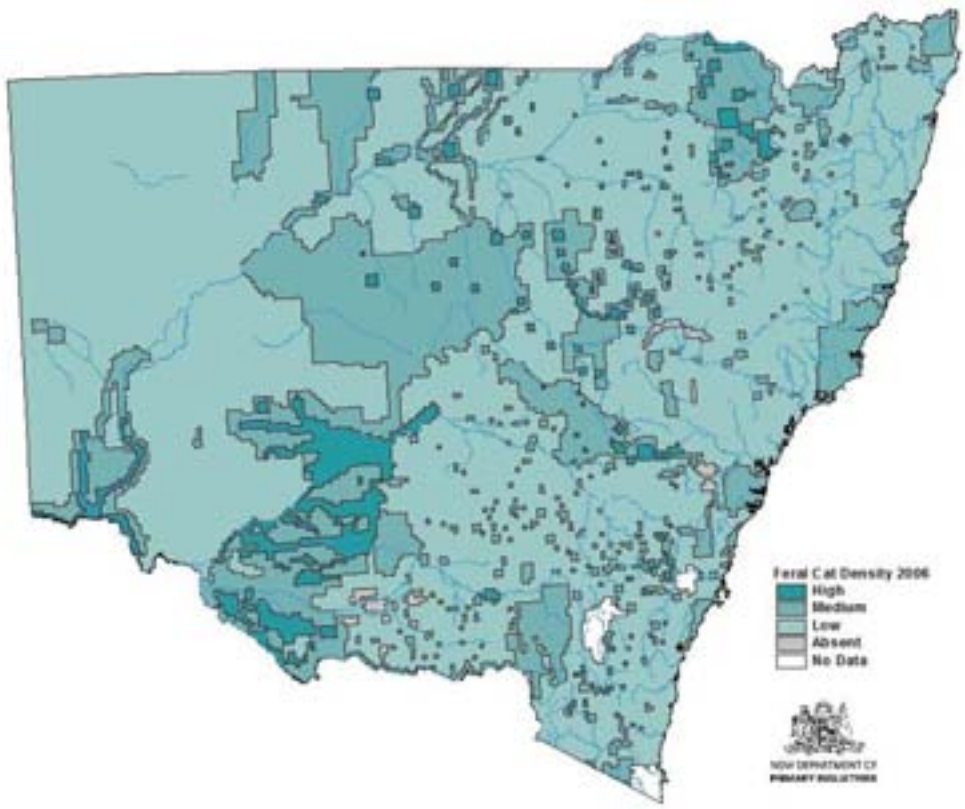

Figure 34. Density of feral cats throughout NSW during 2004.

Table 12. Area inhabited by feral cats throughout NSW (km^2) (with percentage areas in brackets).

Year	Density km^2 (percent of NSW)					
	High	**Medium**	**Low**	**Absent**	**No data**	**Total occupied**
2006	38 638 (4.8)	185 241 (23)	520 861 (64.8)	55 497 (6.9)	3 768 (0.5)	744 741 (92.6)

Control

The management of feral cats is difficult because there are a no formalised control techniques currently available for widespread application, and because feral cats are wide ranging through NSW. Apart from ground shooting, there are few alternative techniques to control feral cats that are target-specific, effective and readily available to land holders. Exclusion fencing can be applied to small areas (at considerable cost); trapping can be labour intensive and may be of limited success; and there are currently no registered chemical control techniques for feral cats.

4.8 European Starling (*Sturnus vulgaris)*


Photo P West

European Starlings were introduced to Australia in the late 1850's mainly by acclimatisation societies, and to destroy crop eating insect pests. Since their introduction they have spread to almost all States and Territories of Australia, and are now recognised as pests to agricultural enterprises, the environment, and society. Starlings are an agricultural pest bird, known to damage horticultural industries, in particular cherries, grapes, blueberries, olives, stone fruits, apples, pears and vegetable crops (Tracey *et al*. in press). They may also carry many parasites and diseases which can be transmitted to a number of animals. Starlings are an environmental pest, competing with native birds for nesting hollows (Tracey *et al*. in press), and have been implicated in the spread of some weeds, such as olives (Tracey *et al*. in press). Starlings are also a pest in urban areas, fouling roof cavities and water supplies. Starlings have a broad diet, and can survive in a wide range of habitats, making it a very versatile pest (Tracey pers. comm. 2006). They are seasonal breeders and can nest in many locations such as crevices in cliffs, tree stumps and eaves under houses. Starlings can also breed very quickly, and often form large swirling flocks that converge on crops and food resources to feed.

Distribution

Throughout Australia, Starlings are commonly observed in lowland suburban and cleared agricultural land in the south east region of the continent. They survive in a wide range of habitats such as open woodlands, mulga, irrigated pasture, feedlots, mallee, reed beds and wetlands, coastal plains and throughout alpine areas (Tracey *et al*. In press). Starlings are tolerant of human disturbance and thrive in cities and towns where they feed off human food scraps (Tracey pers. comm. 2006).

Throughout NSW, information compiled for this survey suggests Starlings are a widespread species that inhabit all Divisions of the State. Their distribution appears scattered throughout many regions of western NSW; however there are few areas where they have not been observed in recent years from the coastal districts, slopes and plains, and tablelands divisions of NSW (figure 35). Areas where Starlings have not been reported throughout the eastern regions of the State are characteristically small-medium sized areas scattered across all Districts (figure 35). There are some areas where no surveys have been conducted (particularly in western NSW) (figure 36) and Starlings are most abundant in the northern and southern slopes, as well as the northern, central and southern tablelands Divisions (figure 37). According to the information provided, Starlings are less abundant along the coastal fringe of NSW than inland (figure 37). Similarly, Starlings are less abundant in western and far-western NSW, possibly because climatic conditions are less suitable to this European species (figure 37).

While information used to form these generalisations about Starling distribution and abundance have come from surveys that are not comprehensive throughout all regions of the State, they provide a meaningful and informative representation of the current status of Starlings where

data supports in NSW. Caution is required, particularly where surveys have been very infrequent, when interpreting this state-wide information.

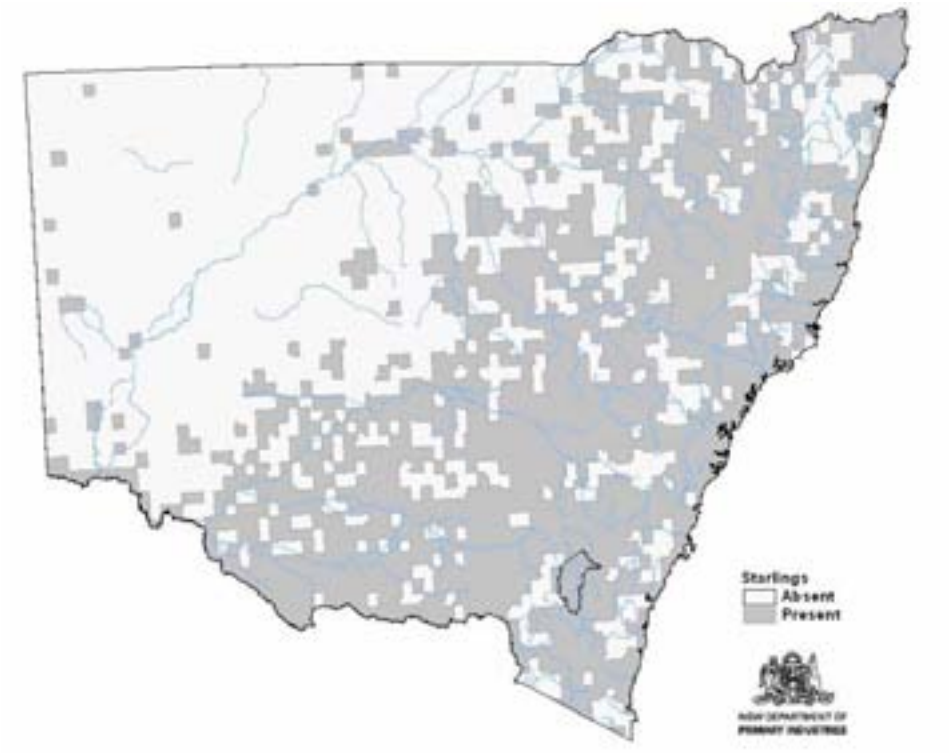

Figure 35. Starling presence throughout NSW and the ACT between 1998 and 2006.

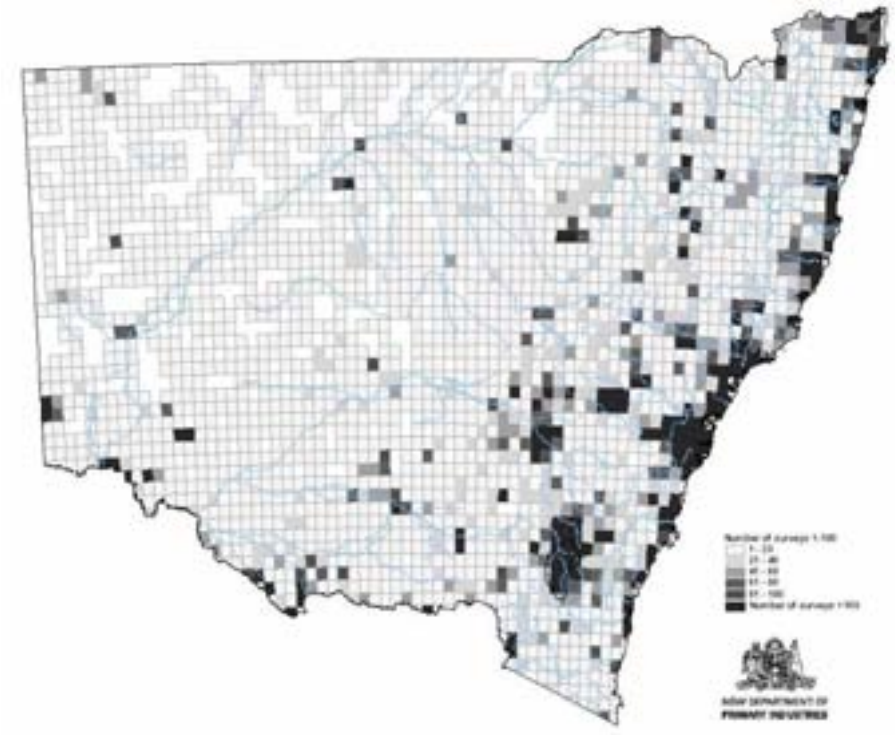

Figure 36. Survey effort for starlings in NSW between 1998 and 2006 (at July 2006)

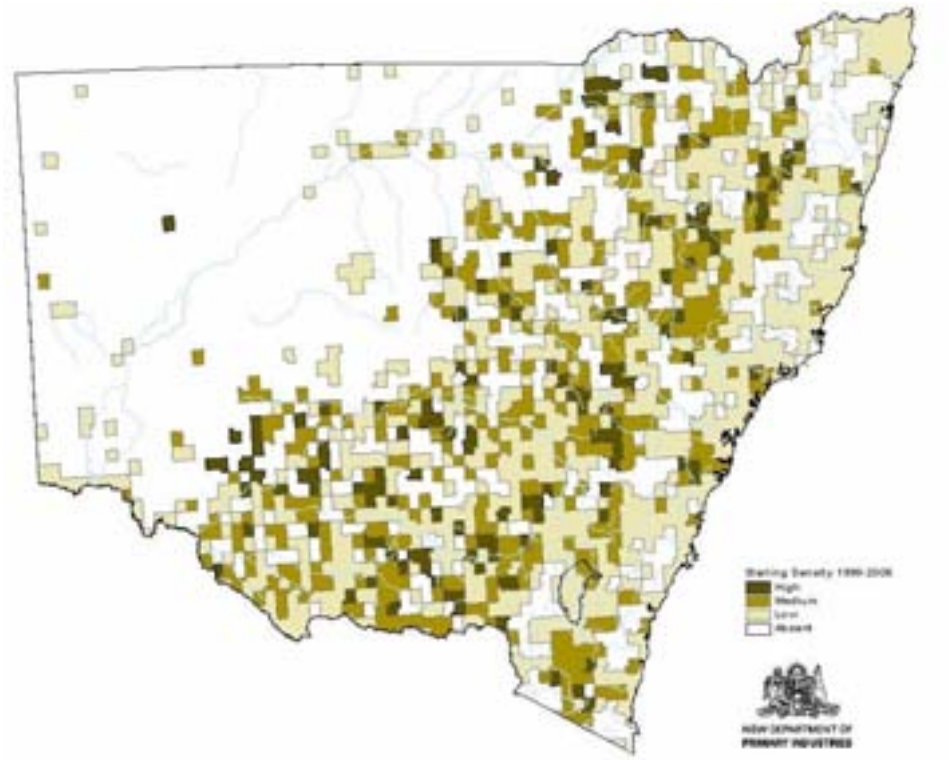

Figure 37. Derived starling abundance from survey reporting rate throughout NSW from between 1998 and 2006.

Control

The management of Starlings in NSW has historically been focussed to areas where their impacts are detected, such as at crops, orchards and vineyards. There are a wide range of techniques available to control pest birds (Tracey *et al*. In Press), however many are expensive, labour intensive and only suitable for application in small areas. While their distribution is widespread, wide ranging control of starlings using these techniques is not likely to be feasible, and alternative strategies are required if broad-scale control is required. Most control activities are tailored to meet specific bird impacts, and damage control is best achieved by aiming measures at specific problem areas (Tracey *et al*. In Press). While largely unconfirmed, an integrated approach to controlling Starlings (using multiple techniques simultaneously) is likely to provide better success than reliance on any single technique. Similarly, a coordinated approach involving multiple land holders and follow-up control is likely to provide better success than one-off localised control. As a result, it is recommended that available control options are identified prior to implementing control where the impacts of Starlings are significant. Multiple landholders should be involved in an on-going or repeated control program if the regional impacts of Starlings are to be reduced. Starlings may breed in urban-residential areas and may move small distances into neighbouring cultivated or cleared agricultural land (Tracey *et al*. In Press). Recognition of these characteristics are important in designing control programs. No information on Starling impacts or control has been gained through the current survey.

4.9 Cane toads (*Bufo marinus)*


Photo: Kimberley Toad Busters Inc. 2007

Cane toads were deliberately introduced in 1935 from Hawaii into cane fields in Queensland to control insects that were destroying sugar cane crops (Molloy and Henderson 2006). Since their introduction, they have become widespread throughout Queensland, and have spread into northern NSW and large areas of the Northern Territory (Molloy and Henderson 2006). While the long-term impacts of cane toads are poorly understood, they are a significant threat to wildlife and domestic pets. Animals that prey on or attempt to eat cane toads are often poisoned by the toxins excreted from glands under the toad's skin (Doody *et al*. 2006). The tadpoles and eggs also carry toxins that affect predators. Cane toads are formidable predators of native fauna, consuming insects, reptiles, and even other frogs. They may compete with native insectivores, transmit disease to native frogs and possibly fish, and cause the displacement of native species, such as the northern quoll and goanna species (Doody *et al*. 2006). Cane toads breed at any time of year, and produce spawn containing up to 35,000 eggs. They grow very quickly in warm weather, reach sexual maturity within one year, and are relatively long lived (Molloy and Henderson 2006). They are particularly tolerant to a wide range of conditions; can survive the loss of up to 50% of their body moisture; survive temperatures ranging from 5-40ºC; and can breed in slightly saline waters (Molloy and Henderson 2006).

Distribution

Cane toads currently inhabit large areas of Queensland, NSW and the Northern Territory. In recent years, the distribution of cane toads has expanded rapidly throughout northern Australia and rapidly westwards towards the WA border (Molloy and Henderson 2006). Although not widely distributed throughout NSW (table 13), established cane toad populations exist in 3 main locations in the north-east of the State (Figure 38). The largest area containing cane toads at high abundance occurs within the Tweed-Lismore RLPB District (between Tweed Heads and Ballina) (figure 38). Other areas known to inhabit smaller populations of cane toads include Port Macquarie and Yamba (figure 38). While these represent the major areas cane toads occur in NSW, there have also been many incidental sightings of cane toads throughout other regions of the state possibly associated with accidental transportation of animals (Lunney, NPWS pers. comm. 2006). However, there are no records of confirmed breeding at these isolated localities.

Table 13. Area inhabited by cane toads throughout NSW (km^2) (percentage areas in brackets).

Year	**Density km^2 (percent of NSW)**				
	High	**Medium**	**Low**	**Absent**	**Total occupied**
2006	2965 (0.3)	67 (<0.1)	295 (<0.1)	800641 (99.6)	3327 (0.4)

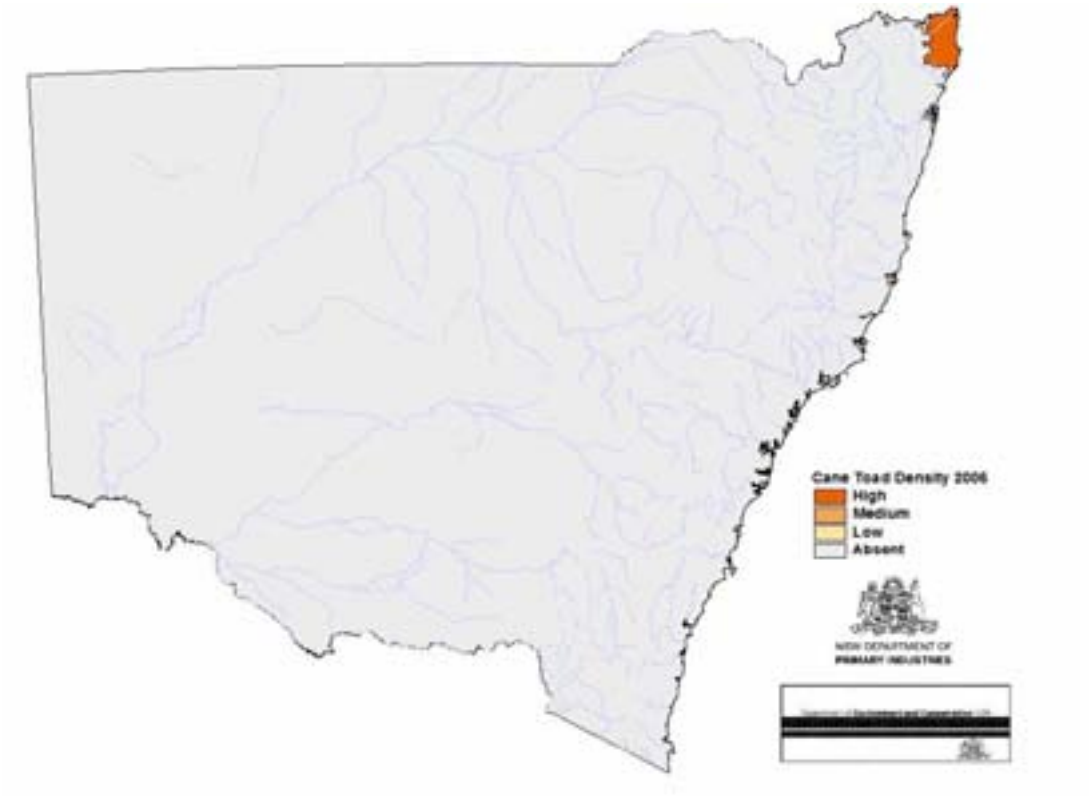

Figure 38: Established cane toad populations and estimated abundance in NSW.

Control

There are few techniques currently available to control large populations of cane toads, however a range of techniques are currently being explored by various research organisations throughout Australia, including gene manipulation technology, sterility and biological control using recombinant viruses (Molloy and Henderson 2006). The most practical control techniques currently available include trapping and manual collection techniques, but these are only feasible on a local scale. There are a range of trap designs and lure techniques, and several methods for manual egg collection and adult toad collection. Establishing effective broad-scale control techniques for cane toads is currently a major priority for control and containment of cane toads in NSW and Australia. Trapping, quarantine control and public education campaigns are strategies currently being used to prevent the spread of cane toads in many areas. Priorities for cane toad management include control technique development, containment of spreading populations and identification of emerging populations (possibly associated with accidental transportation).

This report provides descriptive information captured through consultation with operational staff and field ecologists to report the current status of established cane toad populations in NSW, allowing comparison with future assessment data. It is hoped that improved reporting of cane toads in the wild will assist in containment and control of populations (and reduce their spread) until such time as broad control techniques are available. Reporting of incidental sightings and possible accidental transportation of cane toads, will allow the use of local scale techniques to reduce the likelihood of new populations forming.

4.10 European Carp (*Cyprinus carpio*)


Photo: Source unknown

Carp were likely to have been introduced to Australia during the 1850's and NSW in the 1860's, however the exact release date for carp is unclear (Koehn 2000, Lapidge 2003). However a series of deliberate releases in the 1850s and during the early 1900's has ultimately resulted in carp spreading throughout the Murray Darling Basin and major rivers of NSW (Koehn 2000). Carp are a significant freshwater pest in the rivers of NSW, and are thought to cause a number of impacts including reduced water quality, altered fish species composition, bank erosion, turbidity and reduced aquatic plant growth (Koehn 2000). While debate continues over whether or not they are a symptom or cause of land and river degradation, they can contribute to a range of degrading riverine processes, and they represent a very large proportion of fish biomass throughout the main rivers of NSW. Carp populations also have the potential to increase quickly as females can spawn several times in one season, and produce up to 1.5 million eggs per year. Carp can tolerate a wide range of environmental conditions, breed efficiently, and can survive in water between 4ºC to 35ºC.They can also tolerate extremely low levels of dissolved oxygen, and high levels of water turbidity and salinity for prolonged periods. These characteristics allow carp to inhabit a wide range of river systems in Australia (Koehn 2000).

Distribution

Throughout NSW, European carp are widespread and inhabit the main rivers of the Murray-Darling Basin including the Murray, Darling, Murrumbidgee, Lachlan, Paroo, Castlereagh, Macquarie, Barwon, Gwydir, Namoi, Warrego, Narran and Bogan rivers. They are the most abundant large fish in the Murray-Darling Basin (Koehn 2000, Lapidge 2003). Carp also occur in many large impoundments such as Hume, Keepit and Burrinjuck Dams. Carp are effectively absent from many rivers in the far north-west of NSW that experience prolonged dry periods, and the far north-east coastal and south-east coastal regions. Carp also inhabit many smaller rivers and tributaries throughout NSW. However, abundance in smaller creeks and rivers was not considered significant in proportion to abundance of carp in major rivers.

Control

There are a number of control techniques that are effective at reducing carp abundance (Koehn 2000). Control techniques previously used throughout Australia include commercial harvesting, poisoning, alternative gene technology, biocontrol and sterility options, capture and removal techniques, and carp exclusion devices. Despite these techniques, carp are abundance throughout many rivers of NSW. At present, environmental rehabilitation, direct removal of individuals, and raising pubic awareness of carp as a pest species are strategies being implemented to reduce carp and their impacts throughout NSW rivers.

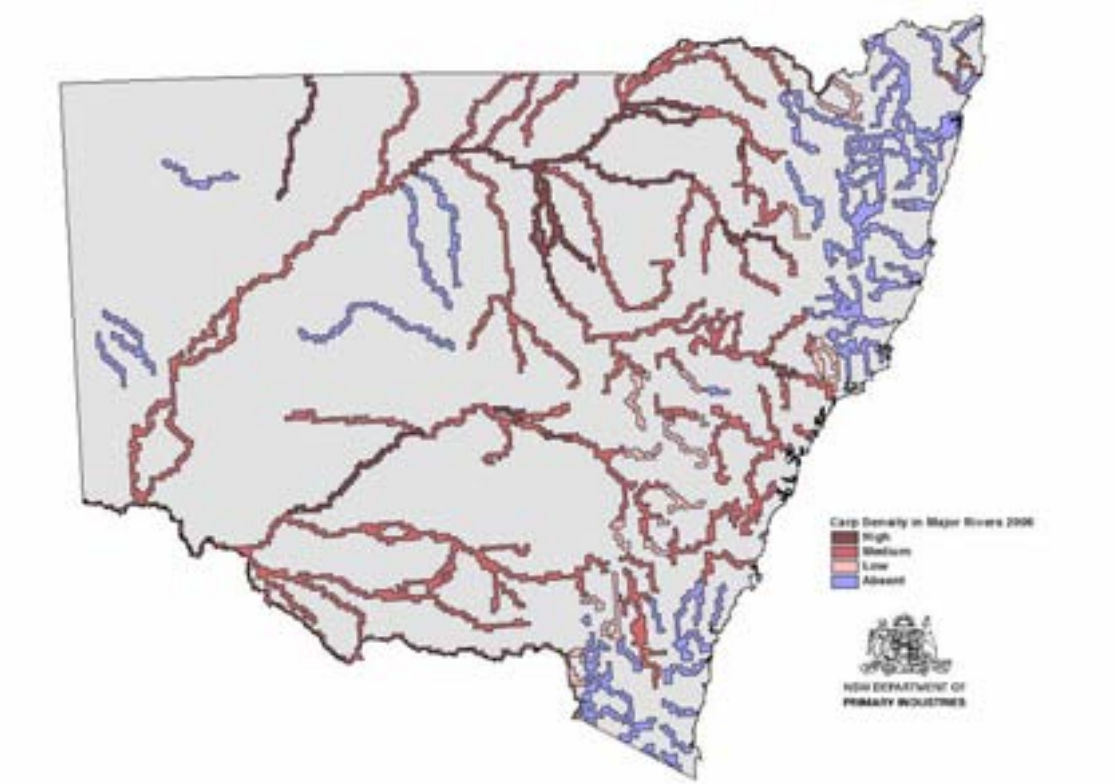

Figure 39: Estimated density of European carp throughout NSW main rivers during 2006.

This report provides generalised information about carp abundance throughout the main rivers of NSW derived from estimates of carp numbers at over 600 sampling locations in NSW (NSW DPI Fisheries), and expert opinion. Carp inhabit all major rivers of the Murray-Darling (Koehn 2000), and a number of large impoundments throughout NSW. It is hoped that improved reporting of carp numbers from minor rivers and creeks, as well as continued sampling of major rivers will assist in determining trends in their abundance over time, identify priority control locations, and facilitate containment of carp to reduce invasion into minor river systems and tributaries. Monitoring and reporting of carp abundance information will also assist in developing and evaluating control strategies to reduce their overall impacts in NSW.

5 DISCUSSION AND MANAGEMENT IMPLICATIONS

5.1 Species overview

Invasive pest animals inhabit all regions of the State, and are well-recognised as causing significant losses to primary production, damaging environmental assets, threatening native species and communities, and impacting on social values. Effective management of pests and their adverse impacts often requires a coordinated approach between government, regional groups and landholders. Information contained in this report represents the findings of one approach in monitoring and reporting aimed at presenting information on the distribution, abundance, impacts and control of pest species to improve their management throughout NSW.

In the years preceding this survey, widespread drought was thought to have caused significant reductions in the extent and associated impacts of many pest species. While localised reductions in abundance, accompanied by reductions in impacts, were observed during this period, broad-scale reductions in animal populations were not apparent. Feral pigs, wild deer, foxes, feral goats, rabbits and wild dogs were all perceived to have endured the drought conditions throughout much of their range. Some species even marginally increased their range. Reluctance or an inability of many landholders to undertake control activities may have lead to some pest populations increasing during this period. Activities such as illegal transportation and release of some species may have also contributed to these trends. Pest animal populations can recover quickly following control. Where localised reductions in pest population may have occurred associated with the drought, follow-up control should be implemented to lessen possible population recovery.

While slight increases were identified in the distribution of many pests over recent years (except species where previous estimates were unavailable), the range of wild deer has increased considerably. Wild deer (comprising 6 species in NSW) have been reported from an additional 30 separate locations throughout the State (representing over 8000km^2). This presents a number of issues, and raises concerns that without development and implementation of cost-effective control strategies, adequate resourcing of control, and on-going surveillance for emergent populations, wild deer may spread further throughout the State. If wild deer abundance continues to rise, they may become prohibitively costly to control.

Localised increases were also observed for other species, however increases in pest abundance does not always directly translate to increases in pest impacts. There were anecdotal accounts of reductions in pest impacts (at least on a local scale) and the types of impacts observed were very similar to those reported during 2002. Definitive estimates of the total economic, environmental and social impacts of pest animals in NSW are largely unobtainable. However, we report changes in the perceived impacts of pest animals between 2002 and 2004/05 as a benchmark for assessing future trends in impacts throughout the State. Measuring and reporting spatial and temporal trends in the impacts of pest animals, particularly in response to control or changes in control practices, is vital for the development of cost-effective management programs. This survey also indicates that the impacts of most species (and control measures implemented to counteract those impacts) were highly varied between Divisions of the State. These findings support a need for region-specific management plans and control strategies to meet the variety of observed conditions, and an equal need for monitoring programs to complement those plans.

The use of control techniques to reduce pest animal impacts during 2004/05 was very similar to those reported in the 2002 survey. Moderate changes were apparent for feral pigs, feral goats, and rabbits, and very slight changes were observed for wild deer, foxes, and wild dogs. No data were available for other species. Commercial harvesting remains an important control technique for several species, and can be used to rapidly reduce populations and often provides an income as a bonus. Recreational hunting is also widely used for pest animal control; however, careful planning and regulation are required to ensure activities are targeted and strategic to maximise their effectiveness at reducing the impacts of pest animals. Poison baiting was also frequently implemented to control the impacts of many pest species. In short, mechanical control techniques were the most commonly used techniques for all species, followed by chemical control, and biological control techniques (rabbits only).

This report provides a valuable state-wide representation of pest animal extent, impacts and control, where more accurate and detailed estimates are not readily available. To minimise perceptual bias and maximise comparability of information, this survey involved 82% of previous survey participants, supporting the validity of its outcomes. However, as this survey presents information from a range of sources and is largely knowledge-based, some differences in opinion and subsequent variance in information are unavoidable. As such, certain assumptions have been made regarding the quality and accuracy of information, and caution is required while interpreting report outcomes. Validation of information would be advisable where fine-scale or localised information is needed for control planning.

5.2 Monitoring and management planning

The development of management plans and monitoring strategies is critical in the process of controlling pest animals and their impacts. There are a wide variety of tools and techniques available for pest control, and land managers need to be aware that planning an integrated approach (using a range of techniques) is considered the best way to reduce the long-term impacts of pest animals. Implementing control techniques in a collaborative program involving multiple landholders within a strategic framework is also important. Furthermore, adopting best-practice management principles through problem definition, identifying the pest species of concern and their geographic range, developing and implementing management strategies, and monitoring outcomes are also crucial steps in pest animal management planning (Braysher and Saunders 2007). In recent years, management authorities and land managers have been encouraged to adopt best-practice principles through assigning pest animal priorities, and by developing management plans through PESTPLAN (Braysher and Saunders 2003).

The findings of the current survey highlight the importance of regional management planning simply because the distribution, abundance and impacts of pest animals are highly varied throughout the State, and no single strategy is suited to all areas. The use of control techniques at differing levels is indicative of this fact. As a result, regional issues require regional planning and control strategies. PESTPLAN can provide a valuable tool to assist land managers develop regional management plans and strategies tailored specifically to regional circumstances (Braysher and Saunders 2003). The PESTPLAN framework aims to improve pest animal management, by setting priorities and developing a specialised regional management plan to meet local and regional management needs simultaneously. The current survey of pest animal populations throughout NSW is complementary to this process, providing generalised and detailed information on populations, enabling land managers to target pest animal populations and measure response to management practices. As a result, mapping of pest animals provides valuable information for planning and the application of best-practice guidelines. Ideally, pest

animal management planning should also be addressed in a broader natural resource management framework, and regional management plans should complement state and national frameworks to meet current and emerging issues at all levels.

Monitoring the success of management strategies and control programs using appropriate methods is also essential to maximise the cost-effectiveness of control activities. In regard to control programs, this can be achieved by carefully monitoring the extent and impacts of pest animals in response to control. Monitoring is important for identifying priorities for management planning and resourcing; evaluating previous management activities; improving understanding and knowledge; and raising awareness and education of issues, problems and opportunities. Relief from the long-term impacts of pests can only be achieved if these principles are applied. Techniques for monitoring pest populations include spotlight counts, aerial surveys, counts of animal sign, trapping techniques and various measurements of animal damage (Mitchell and Balogh 2007).

It is important that meaningful information about the distribution, abundance and impacts of pest animals is available to stakeholders during the planning of control programs. It is equally important for attention to be given to the planning of monitoring activities, particularly monitoring of pest animal impacts in response to control. The information contained herein provides a platform for regional pest animal planning, and a benchmark for ongoing monitoring and reporting activities.

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APPENDIX

Appendix 1. NSW 2004 Pest Animal Questionnaire – Example.

This questionnaire follows on from the pest animal survey of 2002. It presents an opportunity for you to highlight any emerging issues / changes in pest management for your District, and raise any concerns you have with current management practices.

Name/s: _____

FERAL PIGS

For each of the questions below, please circle the most appropriate answer for your District.
*Over the past 2 years, feral pig **populations** in your District have:*
Largely increased Increased Remained constant Decreased Largely decreased Unsure
Reasons ……

*Over the past 2 years the **impacts** of feral pigs in your District have*:
Largely increased Increased Remained constant Decreased Largely decreased Unsure
Reasons ……

When asked about the impacts of feral pigs in your District during 2002, your Board indicated 'spread of weeds' as the greatest impact of feral pigs in your District. How have the impacts of feral pigs changed since 2002? Please re-rank the impacts from highest to lowest (1= greatest impact).

Impacts	**2002 Rank**	**2004 Rank**
Spread weeds	1	
Exotic disease risk	2	
Spread of livestock diseases	3	
Lamb predation	4	
Soil erosion and land degradation	5	
Pasture damage	6	
Damage to watercourses	7	
Predation of native wildlife	8	
Crop damage	9	
Other (please specify)	N/A	

*Over the past 2 years, has the **level of control** of feral pigs in your District changed? Please indicate on the scale below where 0= large decline, 5= constant, and 10= large increase in overall control effort.*

Large decline *Remained constant* *Large increase*

0 1 2 3 4 5 6 7 8 9 10

Reasons ……

When asked about the techniques used to control the impacts of feral pigs in your District, your Board indicated 'recreational hunting' represented 20% of control technique use throughout your entire District. How has the use of techniques changed since 2002? Please estimate the percent use for each technique for 2004.

Technique	**2002**	**2004**
Recreational hunting	20	
Trapping	20	
Ground Shooting	15	
Aerial Shooting	15	
Exclusion fencing	10	
Poisoning 1080	10	
Commercial Harvesting	5	
Poison Baiting- CSSP	5	
Judas Pigs	0	
Other (please specify)	0	
TOTAL	**100 %**	**100 %**

WILD DEER (Red, Rusa, Sambar, Fallow, Chital, Hog and Wapiti, and any hybrids)

Which of these statements most accurately describes wild deer in your District? (tick one box from each group)

Geographic area

Deer are localised to small areas within our management area
Deer are evenly distributed throughout our entire management area
Deer are widespread and scattered throughout all of our management area

Observation location

Deer are rarely observed in the same places
Deer are occasionally observed in the same places
Deer are always observed in the same places

Group size

Deer are most commonly seen solitary
Deer are most commonly seen in pairs
Deer are most commonly seen in groups of 3-10 individuals
Deer are most commonly seen in groups of 11-20 individuals
Deer are most commonly seen in groups of 21-40 individuals
Deer are most commonly seen in large groups of greater than 40 individuals

Movements and mobility

Deer are immobile and move very little within our District
Deer in mobile and move short distances within our District
Deer are mobile and move moderate distances in our District
Deer are extremely mobile and move very large distances in our District

Deer are observed by staff / reported to staff by the public (farmers, motorists etc):

Daily
Weekly
Monthly
Every few months

Once a year
Less than once a year.

The best methods for detecting deer in our District are:

Reports from landholders where damage is occurring
Incidental reports from hunters / motorists / other (please specify)
Organised ground searches involving many people, resources and time
Concurrent pest animal management activities (e.g. aerial shooting activities)
Other (please specify)_____

When asked about the impacts of wild deer in your District during 2002, your Board indicated 'exotic disease risk' as the greatest impact of wild deer in your District. How have the impacts of wild deer changed since 2002? Please re-rank the impacts from highest to lowest (1= greatest impact).

Impact	2002 Rank	2004 Rank
Exotic disease risk	1	
Competition for pasture	2	
Spread livestock diseases	3	
Fence damage	4	
Crop damage	5	
Vehicle accidents	6	
Spread weeds	7	
Other (please specify)	N/A	

When asked about the techniques used to control the impacts of wild deer in your District, your Board indicated there were no techniques used throughout your District. How has the use of techniques changed since 2002? Please estimate the percent use for each technique for 2004.

Technique	2002	2004
Exclusion fencing	N/A	
Repellents (spray & sonic)	N/A	
Aerial Shooting	N/A	
Mustering	N/A	
Ground shooting	N/A	
Other (please specify)	N/A	
TOTAL	**100 %**	**100 %**

FERAL GOATS

When asked about the impacts of feral goats in your District during 2002, your Board indicated 'spread of livestock disease' as the greatest impact of feral goats in your District. How have the impacts of feral goats changed since 2002? Please re-rank the impacts from highest to lowest (1= greatest impact).

Impact	2002 Rank	2004 Rank
Spread livestock diseases	1	
Exotic disease risk	2	
Competition for pasture	3	
Erosion and land degradation	4	
Damage to native vegetation	5	
Fence damage	6	
Spread weeds	7	
Other (please specify)	N/A	

When asked about the techniques used to control the impacts of feral goats in your District, your Board indicated 'exclusion fencing' represented 50% of control technique use throughout your District. How has the use of techniques changed since 2002? Please estimate the percent use for each technique for 2004.

Technique	2002	2004
Exclusion fencing	50	
Mustering	25	
Ground shooting	20	
Aerial shooting	5	
Trapping	0	
Judas goats	0	
Other (please specify)	0	
TOTAL	**100 %**	**100 %**

Is commercial harvesting an important livestock industry in your Board District?
……..

FOXES

When asked about the impacts of foxes in your District during 2002, your Board indicated 'lamb predation' as the greatest impact of foxes in your District. How have the impacts of foxes changed since 2002? Please re-rank the impacts from highest to lowest (1= greatest impact).

Impact	2002 Rank	2004 Rank
Lamb predation	1	
Spread weeds	2	
Predation of wildlife	3	
Spread livestock diseases	4	
Exotic disease risk	5	
Other livestock predation	N/A	
Other (please specify)	N/A	

When asked about the techniques used to control the impacts of foxes in your District, your Board indicated 'poisoning with 1080' represented 50% of control technique use throughout

your District. How has the use of techniques changed since 2002? Please estimate the percent use for each technique for 2004.

Technique	2002	2004
Poison baiting - 1080	50	
Ground shooting	15	
Guard animals	10	
Trapping	10	
Exclusion fencing	10	
Den fumigation	5	
Fox drives	0	
Other (please specify)	0	
TOTAL	**100 %**	**100 %**

Are livestock guard animals being used in your Board district, what types are present, and are they perceived as being effective? (please tick appropriate boxes)

Dogs	Present	Absent	Effective	Ineffective	Unsure
Llama and Alpacas	Present	Absent	Effective	Ineffective	Unsure

RABBITS

When asked about the impacts of rabbits in your District during 2002, your Board indicated 'soil erosion and land degradation' as the greatest impact of rabbits in your District. How have the impacts of rabbits changed since 2002? Please re-rank the impacts from highest to lowest (1= greatest impact).

Impact	2002 Rank	2004 Rank
Soil erosion and land degradation	1	
Competition for pasture	2	
Prevents native vegetation regeneration	3	
Spread of weeds	4	
Competition with native animals	5	
Exotic disease risk	6	
Other (please specify)	N/A	

When asked about the techniques used to control the impacts of rabbits in your District, your Board indicated 'Habitat modification, and 1080 baiting' represented a total of 40% of control technique use throughout your District. How has the use of techniques changed since 2002? Please estimate the percent use for each technique for 2004.

Technique	2002	2004
Habitat modification	20	
Poison Baiting- 1080	20	
Poison Baiting- Pindone	18	
Ripping	15	
Exclusion fencing	8	
Biological control- RCD	5	
Warren fumigation	5	
Commercial/ recreational harvesting	2	
Ground shooting	2	
Blasting	2	
Biological control- Myxo	2	
Trapping	1	
Other (please specify)	0	
TOTAL	**100 %**	**100 %**

DINGOES AND OTHER WILD DOGS (dingoes, feral dogs, and hybrids)

When asked about the impacts of wild dogs in your District during 2002, your Board indicated 'predation of livestock' as the greatest impact of wild dogs in your District. How have the impacts of wild dogs changed since 2002? Please re-rank the impacts from highest to lowest (1= greatest impact).

Impact	2002 Rank	2004 Rank
Predation of livestock	1	
Predation of native wildlife	2	
Spread livestock diseases	3	
Exotic disease risk	4	
Kill farm dogs	5	
Other (please specify)	N/A	

When asked about the techniques used to control the impacts of wild dogs in your District, your Board indicated 'Aerial baiting with 1080, and exclusion fencing' represented a total of 60% of control technique use throughout your District. How has the use of techniques changed since 2002? Please estimate the percent use for each technique for 2004.

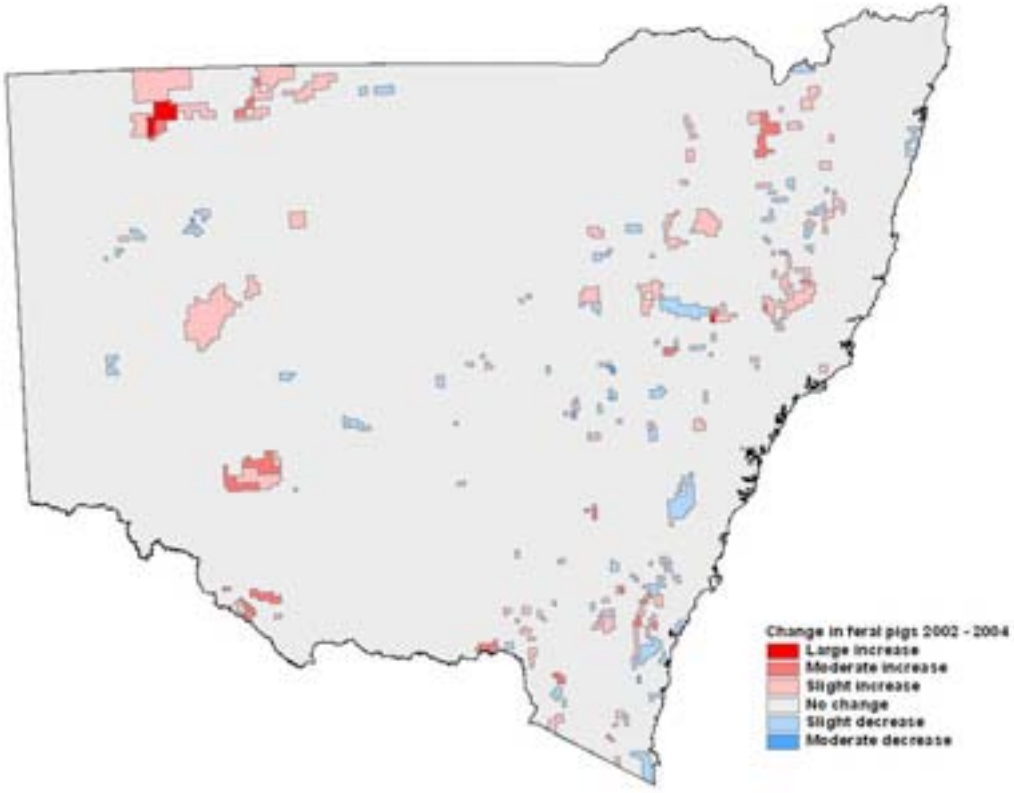
Technique	2002	2004
Aerial baiting- 1080	30	
Exclusion fencing	30	
Ground baiting- 1080	10	
Trapping	10	
Dog drives	10	
Ground shooting	10	
Guard animals	0	
Other (please specify)	0	
TOTAL	**100 %**	**100 %**

Appendix 2. Density/abundance criteria for feral cats.

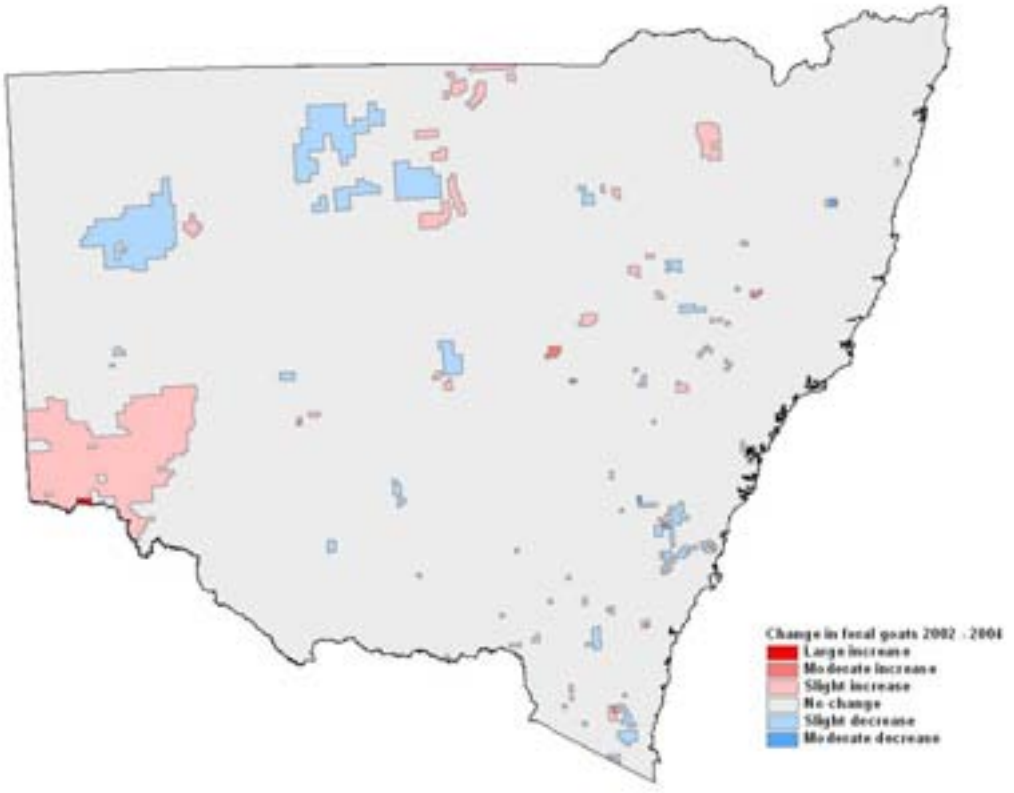
Abundance	Definition
High	*Animals are seen very often, and there is much sign of activity across the area, i.e. reliable sightings or otherwise evidence of high abundance. Best described as observing animals at least 1 in every 5 occasions, or greater than 80% of occasions during spotlighting.* ***E.g. Frequently seen on roads or during control activities for other species at night, occasional sightings during the day, regular reports of impacts from landholders, cat sign abundant throughout the area.***
Medium	*Animals are commonly seen and there is some sign of activity, i.e. frequent but unreliable sightings of animals. Best described as observing animals approximately 1 in every 10 occasions, or on 50-80% of occasions during spotlighting.* ***E.g. Cats are known to occur, sightings and sign are common at night during control activities for other species, or impacts are commonly reported in known areas.***
Low	*Few/ occasional animal sightings or occasional evidence of sign, i.e. rare sightings. Best described as observing animals approximately 1 in every 15-20 occasions, or on 1-50% of occasions during spotlighting.* ***E.g. Sign and observations are occasional, even during night time control activity, no evidence of cat impacts, very infrequent reports. Incidental observations.***
Absent	*No animals or sightings of animals i.e. extremely unlikely to see animals or sign in area. Best described as seeing very little or no sign of animals.* ***E.g. No animals or sign of animals have been observed or reported recently, during any time of the day.***

Appendix 3. Change in the distribution and abundance of pest animal in New between 2002 and 2004 (Note: Dark red denotes large increase; dark blue denotes large decrease).

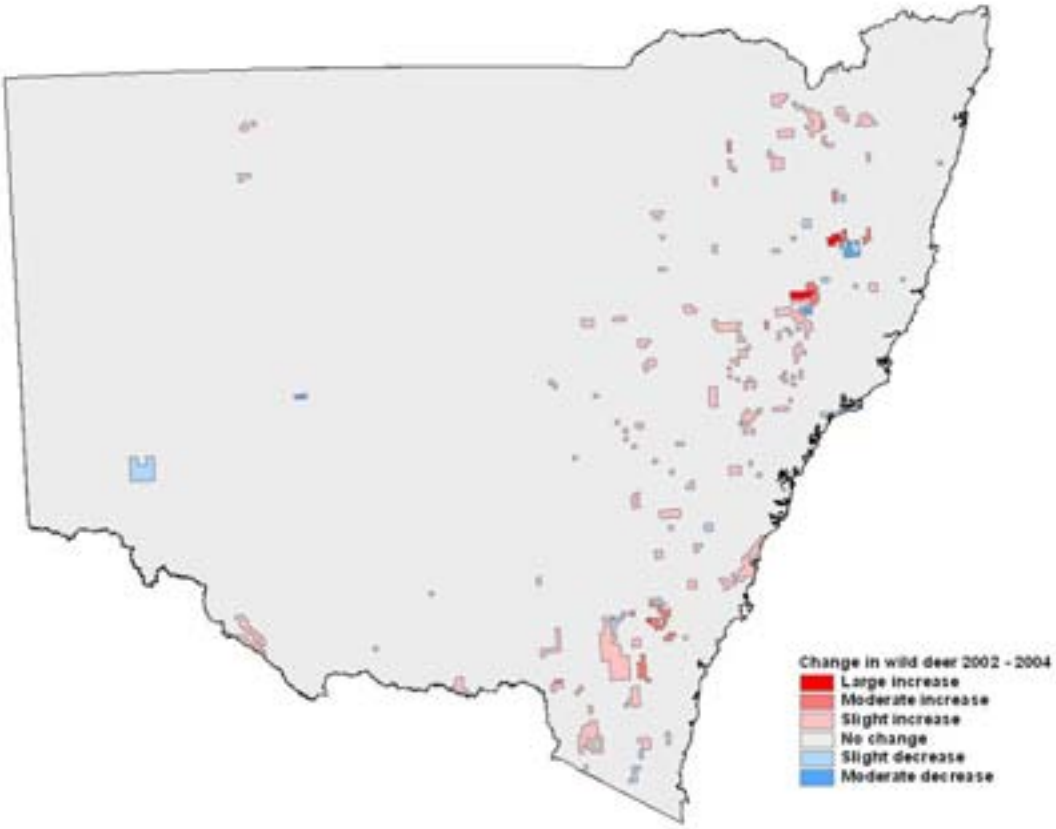
Feral Pigs



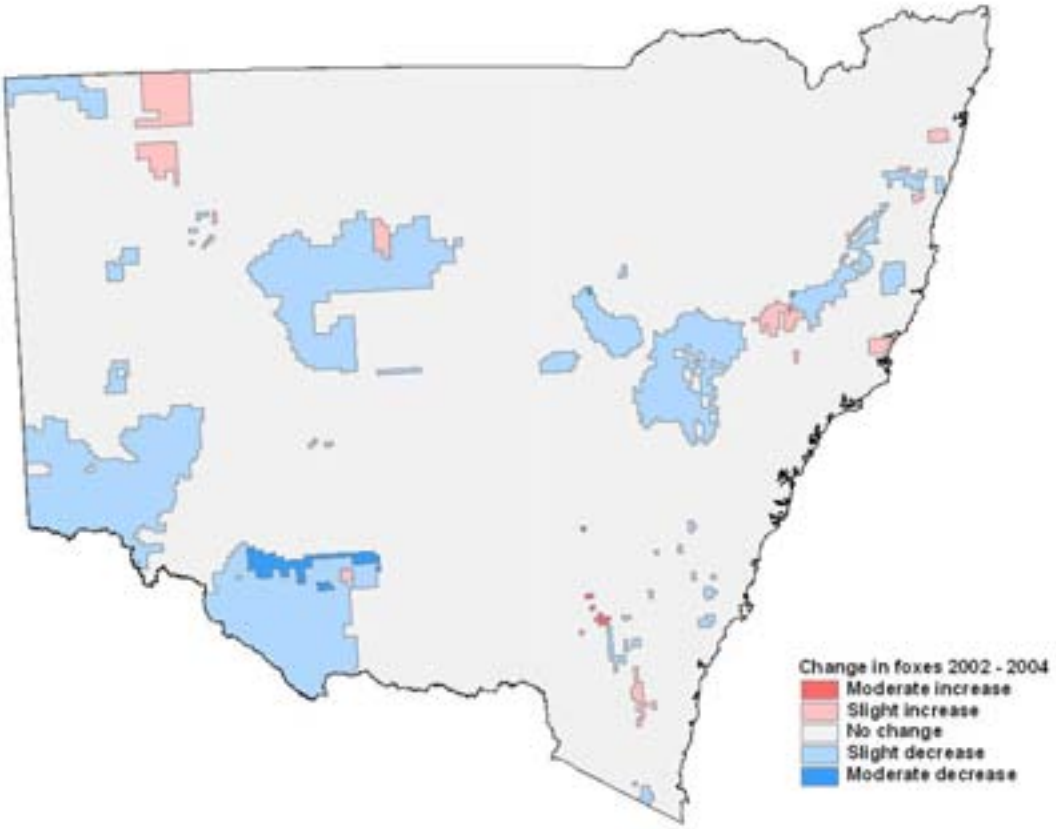
Feral Goats



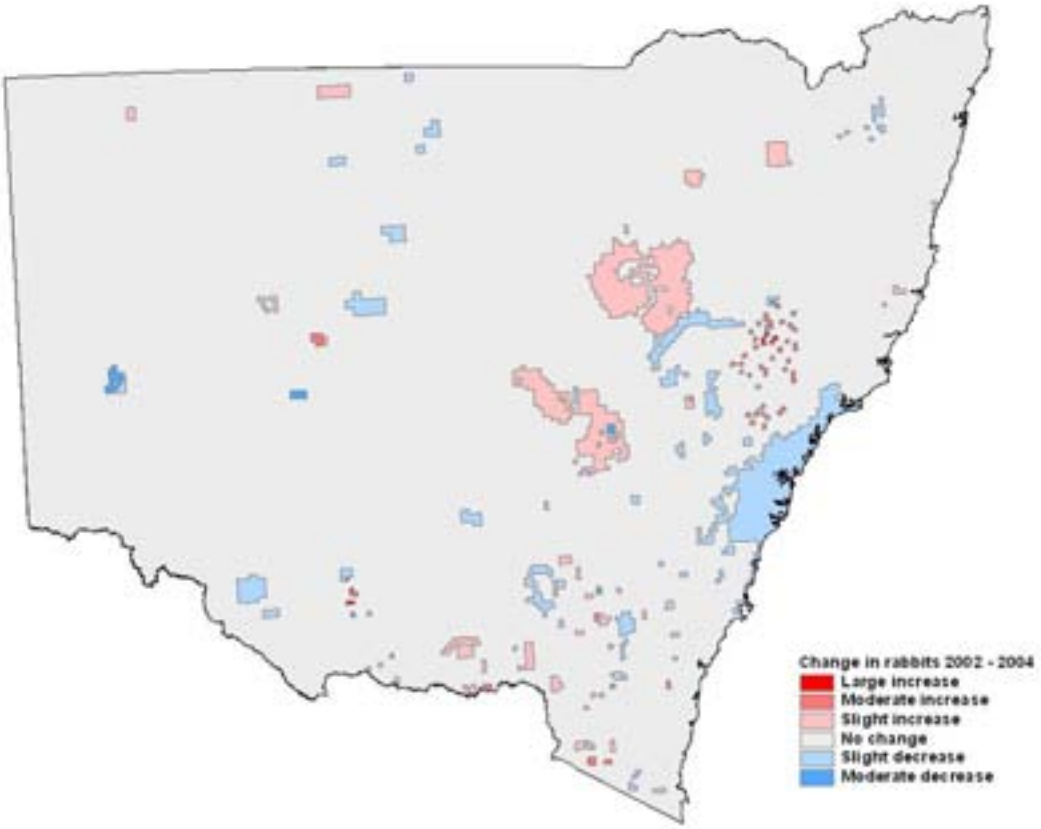
Wild deer



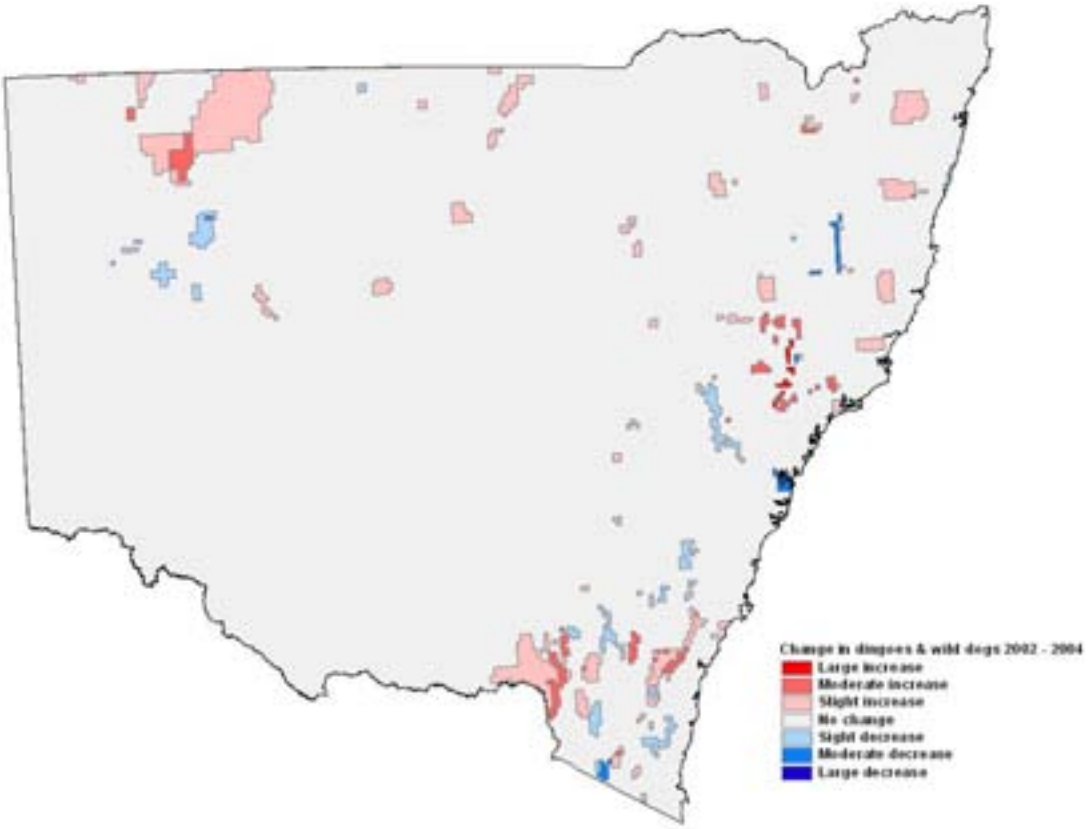
Fox



Rabbits



Wild dogs and dingoes



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