Invasive Animals Cooperative Research Centre

"Together, create and apply solutions"

Summary of State/Territory invasive animal distribution and abundance monitoring.

Gibson, J and West, P (2006).

Project Number: 12D1

Project Title: Mapping Invasive Animals of Australia

Project Leader: Peter West

Date: July, 2006

W: www.invasiveanimals.com E: contact@invasiveanimals.com

This report has been produced in partnership with:

National Land & Water Resources Audit
An Initiative of the Natural Heritage Trust

Disclaimer:

The views and opinions expressed in this report reflect those of the author and do not necessarily reflect those of the Invasive Animals CRC. The material presented in this report is based on sources that are believed to be reliable. Whilst every care has been taken in the preparation of the report, the author gives no warranty that the said sources are correct and accepts no responsibility for any resultant errors contained herein any damages or loss, whatsoever caused or suffered by any individual or corporation.

Published by: Invasive Animals Cooperative Research Centre.
Postal address: University of Canberra, ACT 2600.
Office Location: University of Canberra, Kirinari Street, Bruce ACT 2617.
Telephone: 02 6201 2887
Facsimile: 02 6201 2532
Email: contact@invasiveanimals.com
Internet: http://www.invasiveanimals.com

Publication data: *Summary of State/ Territory invasive animal distribution and abundance monitoring*. Gibson, J, and West, P (2006).

ISBN 0-9775707-5-4

Invasive Animals CRC

CRC AUSTRALIA

Contents

Executive Summary

Invasive animals have major economic, social and environmental impacts in Australia. While substantial investment has been directed to counteract the impacts and damage caused by invasive animals, measurements and monitoring of the distribution, abundance and impacts of invasive animals has also represented an important component of many management programs. Most species have been monitored to set management priorities, plan control activities, measure the success of management programs, and assess the effectiveness of funding initiatives.

National information is required to evaluate the outcomes of national funding initiatives such as the NHT, in addition to various State/Territory and community-based initiatives. National information is also required to address multi-jurisdictional management issues, identify emerging problems, and identify both industry and animal biosecurity priorities.

Meaningful and comprehensive national data on invasive animals to address these matters are often lacking. There is limited information on the distribution of many wide-ranging species, and less information for localised species or emerging pest species. While some State Governments have invested considerable funds towards developing broad-scale distribution and abundance information for invasive animals, the collection, collation and reporting of invasive animals information has not been a major management priority in most States/Territories.

The most comprehensive information on invasive animals is captured and reported within individual State/Territory jurisdictions through State Government programs encompassing primary industries and nature conservation. While all State and Territory jurisdictions have undertaken monitoring of invasive animals, the approaches and techniques used differ considerably, primarily as a result of differences in species, land tenure, primary production, resources, and levels of impact. Monitoring of invasive animal populations has involved either the use of one-off surveys, or a series of repeated measurements of populations. Regardless of the approach used, most programs generate information for species directly relevant to their respective jurisdiction to support decision-making, but rarely apply comparable methods.

Throughout Australia, there are a wide range of methods applied by the relevant State/Territory authorities to measure and report on invasive animal populations. The most widely used method provides regional and state-level information on invasive animals based on qualitative knowledge supported with quantitative data (where available) obtained from face-to-face surveys with local and regional land managers. This approach has been adopted by 4 Australian States. There have also been many initiatives to monitor invasive animals at local scales, primarily in support of on-ground control activities.

There are many different methods used by the States and Territories for monitoring invasive animals, most activities significantly differ regarding species and the methods of information collection, collation and reporting. The largest difference relates to the variables being measured: some programs capture land manager knowledge of animal density using descriptive categories (such as occasional, common, abundant), while others

involve direct field sampling of animal populations. Another major difference relates to the scale of data collection and reporting: scale varies from individual properties to 0.5 degree (approximately 50x50km) areas. As a result, the data obtained from these varying methods often differ in their quality, spatial accuracy, rigour, scale, currency, coverage and the species they address. Despite these differences, most regional and state-scale initiatives result in the production of descriptive information in the form of invasive animal distribution and abundance maps that present valuable information for decision-makers and management authorities. However, most approaches have significant draw-backs, particularly in regard to their comparability. This lack of comparability/uniformity between State/Territory jurisdictions, while justified, prevents adequate comparisons at a national level.

Consistent methods need to be developed and adopted to accurately measure and monitor invasive animal populations to report spatial and temporal trends across multiple jurisdictions. Reporting information within and across State/Territory jurisdictions using a uniform and consistent reporting scale, such as 0.5 degree areas, may provide a framework for on-going consistent data reporting. However, this approach would need to be complemented by consistent data collection at local, regional and state-levels to generate meaningful national data to address current national information requirements.

In addition, to allow national trends in invasive animal populations to be established, it would also be necessary for information from the States/Territories to be readily accessible, or at least stored in a frequently updated centralised national database/information system. Such a system could potentially require considerable infrastructure, as well as flexible data access and exchange arrangements.

The development of national information requires either the development of consistently collected, collated and reported data, or the development of a suitable technique to compare independent and differing data sets across State/Territory jurisdictions. While the latter allows each State/Territory to continue with existing practices, we recommend the development and adoption of a consistent monitoring method applied across all States/ Territories, either complementing, or in addition to existing State practices.

In particular, to allow national information to be presented on invasive animals to address current and future requirements for monitoring, evaluation and reporting, it is recommended that:

1. Nationally agreed data standards are developed and adopted for collection, collation and uniform reporting of invasive animals information;

2. Data are collected using consistent methods at local and regional levels (utilising field manuals and an agreed data reporting framework).

3. Data are collated and reported using a consistent approach at regional and state levels (utilising reporting tools to generate comparable data layers across land tenure and State/Territory jurisdictions); and

4. There are consistencies in reporting products and information management at the State/Territory level to support comparability between jurisdictions and effective reporting of national information.

To achieve these priorities, it is essential to establish a clear and transparent process of method development, data collection, data collation and information reporting involving relevant States/Territories and Australian Governments. Equally important is the need to establish a realistic timeframe to address these priorities, adequately resource the collection and maintenance of data across all levels of Government, as well as develop appropriate infrastructure to address immediate and on-going national reporting priorities, such as evaluating national funding initiatives.

This report summarises the activities and methods used for measuring, monitoring and reporting the distribution and abundance of invasive animal populations throughout the States/ Territories of Australia. It also provides a summary of the data currently available at regional and state-levels to address immediate and on-going reporting requirements. This report recommends priorities for consistency in methods, data, information products, reporting and information management at all levels to address monitoring and evaluation requirements. It also highlights the dependency on adequate resourcing and infrastructure development for nationally consistent information and reporting.

Abbreviations

ABS	Australian Bureau of Statistics
APCG	Animal and Plant Control Group (SA)
APDS	Annual Pest Distribution Survey
ARI	Arthur Rylah Institute
BRS	Bureau of Rural Sciences
CALM	Conservation and Land Management
CAS	Catchment and Agriculture Services
CMA	Catchment Management Authority
COG	Canberra Ornithologists Group
CRIS	Client Resource Information System
DAFF	Department of Agriculture, Forestry and Fisheries
DAFWA	Department of Agriculture and Food Western Australia
DEC	Department of Environment and Conservation
DEH	Department of Environment and Heritage (Federal)
DEH SA	Department of Environment and Heritage (SA)
DNRETA	Department of Natural Resources, Environment and the Arts
DNRMW	Department of Natural Resources, Mines and Water
DPI	Department of Primary Industries
DPI&F	Department of Primary Industries and Fisheries
DPIW	Department of Primary Industries and Water
DSE	Department of Sustainability and Environment
DWLBC	Department of Water, Land and Biodiversity Conservation (SA)
EIS	Environmental Information System
EPA	Environment Protection Agency
IA CRC	Invasive Animals Cooperative Research Centre
IPMS	Integrated Pest Management System
NAP	National Action Program
NHT	Natural Heritage Trust
NLWRA	National Land & Water Resources Audit
NM&EF	National Monitoring and Evaluation Framework

NNP	Namadgi National Park
NPWS	National Parks and Wildlife Service
NRM	Natural Resource Management
PIMS	Primary Industry Management System
PIRSA	Primary Industries and Resources SA
PWS	Parks and Wildlife Service
QPWS	Queensland Parks and Wildlife Service
RLPB	Rural Lands Protection Board
SLIP	Shared Land Information Platform
SOE	State of the Environment
VPRU	Vertebrate Pest Research Unit
WEDPP	Wildlife and Exotic Disease Preparedness Program

1. Introduction

1.1 Background and Purpose

The environmental, social and economic impacts of invasive animals impose major costs on Australia every year (Woolnough *et al*, 2005). The annual impact costs of the main introduced invasive animals, such as feral pigs, feral goats, European rabbits and Red foxes have been estimated at $720 million (McLeod, 2004). There are 25 exotic mammals, 20 birds, one amphibian and four reptiles that have established stable wild populations in Australia (Bomford, 2003), and many of the impacts of these species are long-term, poorly understood and/or difficult to measure.

Information on the distribution and abundance of invasive animals is fundamental for management planning and prioritization, and is a vital precursor for the implementation of effective management strategies, such as targeted control programs. Information on the distribution and abundance of invasive animals is also necessary for an assessment of the effectiveness of control activities where impacts information may be unavailable. Invasive animal populations are also measured or monitored for impact assessment, developing management programs, and disease contingency planning.

Throughout Australia, most monitoring programs have focused on reporting the status of invasive animals for the purpose of regional and State-level management. The species most commonly monitored are those causing damage to the environment and agricultural production, including large herbivores, introduced predators, and rabbits. The impacts of species often vary throughout their range; consequently, the initiatives to measure invasive animal populations also vary between regions.

There are a wide range of methods that have been used for monitoring invasive animal populations, they include surveys of institutional knowledge (Woolnough *et al*. 2005), transect and spotlight counts, sand-pad monitoring, live trapping, and aerial surveys. Other indirect methods, such as control programs, damage assessment and incidental observations often provide information on the distribution and abundance of many invasive species. Most of the methods adopted to measure populations of invasive animals differ in the quality of data they provide, their appropriateness for species and habitat types, and sensitivity and robustness for detecting change in animal populations. As a result, some unavoidable problems emerge when comparing outcomes of assessments derived from different monitoring techniques.

While many programs and initiatives have produced broad-scale assessments of animal abundance, others have focused on intensive monitoring of populations in response to localised control treatments, and provide local and regional datasets to support decision-making. Often complementing these programs are assessments

of the impact of species in response to treatments. However, impact measurements are usually localised because of difficulties associated with measuring impacts across large areas.

The purpose of this report is to:

1. Summarise the monitoring methods used throughout the States and Territories of Australia for measuring and reporting the distribution and abundance of invasive animal species.
2. Provide an overview of the state and regional-scale spatial data available on the distribution and abundance of invasive animals to address requirements for national monitoring, evaluation and reporting.

1.2 Relevance of Review for National Invasive Animal Monitoring

Monitoring of invasive animals is imperative for efficient management of populations and their impacts. National monitoring provides information to: assess the effectiveness of funding initiatives, determine priorities for control programs, disease surveillance, and contingency planning, and guide multi- jurisdictional management programs.

The National Land & Water Resources Audit (NLWRA) is a Federal Government initiative of the Natural Heritage Trust (NHT). The primary goal of the NLWRA is to provide data, information and nationwide assessments of Australia's land, water and biological resources to support sustainable development. Their commitments also include reporting the status of invasive animals throughout Australia under the National Natural Monitoring and Evaluation Framework (NM&EF). The NM&EF has been developed by the Australian, State and Territory Governments to help monitor and report on the impact of the National Action Plan (NAP) and Natural Heritage Trust. The NM&EF sets out broad "Matters for Target" which are to be reported on, using a range of indicators. A key role for the NLRWA is to report against these Matters for Target and Indicators, with the aim of assisting, over time, the evaluation of the effectiveness of the NAP and NHT and other natural resource management initiatives (NLWRA website).

The NLWRA and Invasive Animals Cooperative Research Centre (IA CRC) have collaborated to address current and future needs for national invasive animal information. The collaboration ensures that vital information on the current status of invasive animals is determined, and national and local benchmarks for invasive animals are established from which monitoring and evaluation can be performed. Reporting of current information on the distribution and abundance of invasive animals is required to address priorities under the National Monitoring & Evaluation Framework.

1.3 Objectives

This summary document provides information to establish the range of methods used to monitor invasive animal populations to interpret the suitability of information for national mapping.

The objectives of this report are:

1. Describe the previous and current methods and monitoring programs used to measure the broad scale distribution and abundance of invasive animals throughout Australia.
2. Identify spatial data on the distribution and abundance that may address the current and on-going national monitoring, evaluation and reporting requirements.
3. Identify the information management tools and information products used to manage and report invasive animal information.
4. Summarise State and Territory information to support the development on national protocols for measuring and reporting invasive animal information for on-going monitoring, evaluation and reporting requirements.

1.4 Methods

This report summarises information obtained from a variety of sources, including literature and reports, and consultation with State/Territory Agencies (Appendix 1).

Reports, literature and website material were reviewed to obtain information about previous and current initiatives to measure and report invasive animal distribution and abundance information from the States/Territories. Various Government publications, including reports on the outcomes of dedicated monitoring programs, and technical documents were supplied to prepare this summary report.

Representatives from State and Territory Government Agencies spanning primary industries, natural resource management and conservation were also consulted to obtain information on previous and current programs and initiatives to measure invasive animal populations. Consultation involved three phases:

- Discussions and correspondence during program development;
- Correspondence and reporting of Agency information; and
- Comments from agencies on drafts of this summary report.

This report captured and summarised information on:

- Agencies/organisations responsible for management and monitoring;
- history of monitoring and associated activities;
- species of importance and species for which information has been collected;
- spatial scale, location and area monitored during programs;
- monitoring and survey design;
- period of information collection and frequency of on-going initiatives;
- available information for species involved in monitoring;
- the products, outputs and outcomes of surveys and monitoring;
- assumptions of data, verification of information, and, data accuracy; and
- data custodians, management, and information systems.

Representatives from State and Territory Agencies also reported on the issues associated with programs and survey initiatives.

Information contained in this summary provides a platform for interpretation of State-level spatial data on invasive animals for immediate and on-going national reporting requirements. It also supplies valuable information on collection, collation and reporting of invasive animal information to guide the development of consistent reporting, and the development of agreed data collection standards.

1.5 Invasive Species

The Invasive species that have been considered in this report are those classified as pest animals of potential national significance given current State/Territory declarations and recommendations from State/Territory Government. Fish and birds have not been included in the summary. The species recommended for this review were European rabbit, Red fox, wild deer, feral pig, feral goat, wild dog and dingo, wild horse, feral cat, feral buffalo, feral camel, feral donkey, and feral cattle and sheep. Information on other species, such as Red-eared Slider Turtles, macropods and some native species were collected where feasible.

2. State and Territory Information

2.1 Victoria

Responsibility for management

The Department of Sustainability and Environment (DSE) has primary responsibility for the management of vertebrate pests in Victoria. The Department of Primary Industries (DPI) within DSE, Victorian Vertebrate Pest Research Unit (VPRU), Arthur Rylah Institute (ARI), and the Catchment and Agricultural Services (CAS) also have various responsibilities for pest animal management in public and private land. Parks Victoria are also responsible for the management of pest animals in Reserves, Parks and Wilderness Areas of the State (Department of Sustainability and Environment website).

The Catchment and Agricultural Services (CAS) work directly with private landowners and managers in preventing and managing pest plants and animals that threaten Victoria's agricultural industries, natural environment and biodiversity. The CAS regulates the *Catchment and Land Protection Act (1994)* to protect natural assets and the environment (B. Harrison, CAS, Victoria, pers. comm. 2006).

History of pest animal monitoring

The monitoring of pest animals throughout Victoria has previously involved intensive monitoring of a small number of species within selected regions, rather than broad-scale monitoring of a wide-variety of species.

Department of Primary Industries (DPI)

From 1998-2001, 20 monitoring sites were established in rabbit prone areas. These surveys involved vehicle transects varying from 8 to 20 km in length, depending on the site. Within these transects, active warren monitoring occurred which involved active entrance counts.

More recently, randomly chosen rabbit transects were established to indicate catchment health using a scoring scale based on rabbit activity, derived from active warren entrances, and potential to increase, rather than actual rabbits seen or counted. These 100m transects were walked by field officers and data was collected on sightings, scratchings, warrens and rabbit sign.

A project combining the above methods has now been developed. It involves 17 sites (of the 20 previously surveyed from 1998- 2001) that are monitored biannually incorporating 400m walked transects and warren activity monitoring (S. McPhee, Victoria DPI, pers. comm. 2006).

Catchment and Agricultural Service (CAS)

Information on the presence of wild dogs has been maintained by CAS from records of dog baiting activities throughout the State (B. Harrison, pers. comm., 2006).

Parks Victoria

Parks Victoria has previously monitored vegetative responses to changes in rabbit grazing, and fox populations within selected National Parks (Vertebrate Pest Indicator Submission, 2006). Information on the presence of foxes within private landholdings may also be available from records maintained during the implementation of the fox-bounty program throughout Victoria (J. Wright, Parks Victoria, pers. comm., 2006).

Arthur Rylah Institute, Parks Victoria, DPI and CAS

Fox presence has been monitored in the Southern and Glenelg Ark projects by the ARI, Parks Victoria, DPI and CAS.

Species of Importance regarding economic, environmental and social impacts

Vertebrate pests that are of particular significance to Victoria include:

- European rabbit
- Red fox
- wild dog/dingo
- feral horse
- Indian myna
- feral pig
- feral goat
- wild deer
- red-eared slider turtle
- European starling

Species targeted for data collection during recent surveys

Three species have been the focus of monitoring throughout areas of Victoria, these are: foxes, rabbits and wild dogs/dingoes. The *Victorian Pest Management Plan – A Framework for Action* identifies rabbits, foxes, wild dogs/dingoes, feral goats and feral pigs as declared pests under the *Catchment and Land Protection (CaLP) Act 1994*. Despite this, there is limited information on the distribution and/or abundance of feral pigs and feral goats throughout the state.

Geographic range and scale of data

In Victoria, the type and scale of data available on the distribution and abundance of pest animals varies between species.

Rabbit information has been collected within several regions (transect monitoring sites) providing trend data in animal abundance. Rabbit information has also been obtained throughout some National Parks and Reserves, but is scarce in other areas due to the sampling design of past and current projects (random and focused site selection). State-wide maps are not available for rabbit distribution or abundance (M. Johnston, DPI, pers. comm. 2006).

Information of the distribution and abundance of foxes may be obtained from three sources in Victoria: bounty records, monitoring within selected national parks and reserves, and monitoring associated with the Southern and Glenelg Ark projects. State-wide maps are not available for foxes.

Information on the distribution and abundance of wild dogs/dingoes is available from records on control activities on private land maintained by the CAS. There are no state-wide monitoring programs or datasets available for wild dogs/dingoes throughout Victoria.

There have been no attempts to collate current information to generate state-wide distribution and abundance maps for pest animals in Victoria (M. Johnston, pers. comm., 2006). There were no sources of information identified on the distribution and abundance of wild deer, feral cats, wild horses, and pest birds throughout Victoria.

The Wildlife Atlas is maintained by DSE and contains information on the presence of species throughout the entire state (Spatial Vision, media release, 2005). However, this is not anticipated to provide comprehensive information on many pest animal species.

Method of information collection and reporting

Agencies involved

Department of Sustainability and Environment (DSE)

The DSE are responsible for coordinating data collection throughout the state. They support the provision of services through DPI, CAS, Parks Victoria and the ARI focusing on on-ground management and monitoring at regional and local levels.

Department of Primary Industries, Catchment and Agriculture Service, and Arthur Rylah Institute

These agencies are largely responsible for on-ground control activities and the implementation of measures to assess the effectiveness of control. The CAS obtains data on locations and numbers of wild dogs on private land that have been trapped or killed. This provides presence information and a measure of abundance (B. Harrison, pers. comm., 2006).

The DPI, ARI and Parks Victoria work collaboratively on the Southern and Glenelg Ark projects, undertaking spotlight and sand-pad monitoring, and regular baiting of foxes.

The Victorian DPI have been responsible for collecting data on rabbits. They are monitoring rabbit numbers by using transects positioned throughout the state that incorporate warren activity. This is performed twice a year and is focused upon areas that are known to have high numbers of rabbits present (S. McPhee, pers. comm., 2006).

Parks Victoria

Parks Victoria undertakes a range of monitoring activities measuring the distribution and abundance of pest animals. Most monitoring focuses exclusively on Parks and Reserves, and involves reporting the presence of pest species by trained staff.

Passive tracking, sand-pad monitoring, spotlight surveys and bait take are used to monitor foxes in some areas. The impacts of foxes have also been identified in a variety of sites and situations. Parks Victoria has monitored vegetative responses to changes in rabbit grazing within selected National Parks. Some native species, such as the kangaroo have been the focus of intensive and long-term monitoring for assigning quotas. Parks Victoria also undertake *State of the Parks* reporting every 5 years throughout the State that includes information on pest animals (J. Wright, pers. comm., 2006).

The Southern and Glenelg Ark projects in Victoria involve many of these Agencies.

The Southern Ark Project is a large-scale fox control project in south-eastern Australia (East Gippsland) that builds on many years of research that confirms the positive impact that fox control has on the health of ecosystems. The fox control program will be monitored using bait-take from the bait stations, the occurrence of fox footprints on sand-pads established at regular intervals across tracks, and the collection of scats from along certain tracks. Complementing this is native mammal monitoring using cage-trapping and hair tube monitoring (G. Friend, pers. comm. 2006).

The Glenelg Ark Project is a project targeting fox control and wildlife monitoring in far western Victoria that aims to reduce fox predation on native wildlife throughout 100,000 hectares of forest. Fox control involves fox baiting and wildlife monitoring focusing on Southern Brown Bandicoots, Long-nosed Potoroos and Heath Mice (G. Friend, pers. comm., 2006).

The Wildlife Atlas is maintained by DSE reporting species location information (sightings mainly) from throughout the State.

Period of data collection

Department of Primary Industries, Catchment and Agriculture Service, and Arthur Rylah Institute

Information on the presence of wild dog/dingoes in regions of Victoria have been recorded by CAS as part of control activities and baiting for many years. The Wildlife Atlas is an on-going database of species records. Monitoring of rabbits through numerous state wide transect counts and warren observations has occurred since 1998 (B. Harrison, pers. comm., 2006).

Parks Victoria

Monitoring of rabbits in the Parks and Reserves has increased since the advent of rabbit calicivirus disease in 1996. Fox monitoring has also increased in recent years within Parks Victoria managed areas.

Ongoing data collection

Data collection associated with monitoring the distribution and abundance of vertebrate pests is often associated with control activities. Information on the presence of wild dogs from CAS is expected to be maintained as long as CAS

retains responsibility for assisting in wild dog management. Information on rabbits and foxes in Reserves and Parks administered by Parks Victoria is expected to be maintained regularly. Additionally, rabbit monitoring by the DPI will continue to evolve and expand where possible.

The Southern and Glenelg Ark Projects are expected to operate for many years, providing accurate information on fox and wildlife abundance in selected areas of the State.

The Victorian Pest Management Framework proposes to develop monitoring and reporting protocols, and to transfer information on pest abundance from a variety of sources into the IPMS. Standard monitoring protocols for foxes, cats, rabbits, and deer have been drafted by Parks Victoria, DPI, DSE and ARI to support the collection of information on pest animals throughout Victoria (Parks Victoria, Threat monitoring protocols, 2004).

The Wildlife Atlas database contains records maintained by DSE providing on-going information on the presence of species. The database is an on-going initiative by DSE to gather data on many wildlife species.

Available information

DSE maintains information that has been developed largely to address regulatory activities. Most information available for pest animals in Victoria has been gathered for selected areas under the management of either Parks Victoria, for control activities, or specific programs such as large collaborative predator control programs.

Information to address the distribution and abundance of various pest animals in Victoria may be obtainable from:

- the CAS for information on the presence of wild dogs/dingoes based on baiting activities;
- Parks Victoria for rabbit and fox information within selected Parks and Reserve areas throughout the State;
- Victoria DPI for rabbit distribution and abundance and active warren monitoring;
- the Southern and Glenelg Ark projects for fox and wildlife abundance records; and
- the Wildlife Atlas that may contain records to determine the geographic extent of some pest species throughout the State.

Aggregation of existing data

There is no large-scale datasets currently aggregated to form State maps for pest animals in Victoria.

Strengths and weaknesses of existing methods and data for State-wide reporting

Strengths

(1) Most information represents presence data of high quality from dedicated surveys involving spotlighting, sand pads, and sighting records.

(2) Some regions have monitoring data available for consecutive years.

Weaknesses

(1) State-wide data and distribution maps are unavailable.

(2) Distribution and abundance information is available for three species: fox; rabbit; and wild dog/dingo.

(3) Multiple agencies have been involved in collecting and collating pest animal information making it difficult to form a consolidated dataset for pest animals in Victoria.

(4) The most recent DPI rabbit monitoring information is taken from only rabbit prone areas across the state.

Products of information

Maps and documents

Currently, there are no state wide distribution and abundance maps for vertebrate pests in Victoria. The Victorian Pest Management: A Framework for Action document provides guidance for effective monitoring and reporting of pest animal information throughout the State. At a regional scale, there are a variety of reporting products for distribution and abundance monitoring programs (one-off and on-going). These are available from respective Agencies.

Reporting frequency

Annual reporting by the Victorian Catchment Management Council represents the only identified regular reporting mechanism within Victoria regarding the status of pest programs throughout the State, and it is unclear whether reporting addresses distribution and abundance information. With the exception of Catchment Management Council reporting, there are no regular reporting requirements for agencies within Victoria specifically addressing distribution and abundance information. Reporting has largely focused on the independent projects /programs throughout regions of the State.

The monitoring protocols developed by ARI and the Victorian Pest Management Framework provide guidance on monitoring throughout the State. The Framework indicates that the Catchment Management Authorities (CMA's) will be required to produce annual reports at regional and local scales. These are anticipated to improve the collection, collation and reporting of pest animal information (abundance and impacts information) throughout the State.

Assumptions of data

The monitoring methods used for gaining information on pest animal distribution and abundance have included transect and spotlight surveys, and sand pad monitoring. It is assumed that these types of surveys are sufficiently capable of detecting pest animals throughout their range.

Verification of data

Most existing information throughout regions where monitoring of distribution and abundance has been undertaken, has involved the reporting of presence data. Data has commonly been obtained from either one-off or on-going initiatives, and it is not clear whether presence information requires confirmation.

Density estimates or qualitative information regarding species data may warrant some form of verification prior to preparing State-scale maps of pest animal abundance.

Data management

Catchment and Agriculture Service, Department of Primary Industries

The data collected from the Catchment and Agriculture Services (CAS) and the Department of Primary Industries (DPI) is managed in small databases that contain the presence data of captured and killed animals, in particular wild dogs/ dingoes. Combined, these databases contain state wide data originating from each on ground management group (J. Backholer, DPI, pers. comm. 2006).

Parks Victoria

The data that is obtained by Parks Victoria is maintained within small databases however they are currently trying to establish a centralised database which will enable data sharing and the production of broad-scale information products (C. Watson, Parks Victoria, pers. comm., 2006).

Southern and Glenelg Ark projects

The data from both the Southern and Glenelg Ark projects are maintained by the local project manager from each region. This data is then analysed and reported by Ark operations staff and staff from the Arthur Rylah Institute (ARI) (G. Friend, pers. comm., 2006).

Data custodians

The Department of Sustainability and Environment (DSE) and Parks Victoria are the custodians of the all data described herein regarding pest animals throughout Victoria.

Information systems

Integrated Pest Management System

The Integrated Pest Management System (IPMS) provides a recording, evaluation and reporting database used by regional staff involved in pest plant and animal activity in DSE. IPMS supports the management of strategically significant pest

plant and animal infestations within the context of the Victorian Pest Management – A Framework for Action. IPMS focuses on compliance programs, Weed Alert Rapid Response, Good Neighbour Program and the sale of poison baits. IPMS stores standardised descriptions of infestations; details of regulatory actions and control activities; and administrative information associated with the sale of poison baits. IPMS can be used with Arcview for spatial mapping (Backholer, 2005).

During 2004, a 'bait management module' within IPMS was implemented. It handles information associated with the sale of poison baits to private and public land managers.

Parks Victoria has a customised Environmental Information System (EIS) that records actions undertaken to manage natural values. EIS contains a pest animal module where field staff can map the locations of target species, management actions and any method of control. It is used to prepare annual reports about activity and provides parks staff with a system to spatially record and review management actions. Areas where control of pest animals has occurred can be used to infer distribution information for various pest animal species. However, this system records information for Parks and Reserves only.

2.2 New South Wales

Responsibility for management

Responsibility for the management of pest animals in New South Wales is determined by 6 legislative Acts (Commonwealth of Australia 2005). The primary authorities responsible for regulating the legislation include the Rural Lands Protection Boards (RLPB), NSW Department of Environment and Conservation (DEC), and NSW Department of Primary Industries (DPI). There are no legislative requirements in New South Wales to record and report on the distribution, density and impacts of pest animals under current legislation.

History of pest animal monitoring

NSW Department of Primary Industries

In NSW over the last 30 years there have been five state-wide surveys of vertebrate pests. There have been surveys undertaken in 1979, 1985, 1996, 2002, and 2004 (Vertebrate Pest Indicator Submission, 2006). The latter two produced maps detailing broad variation in pest densities. NSW Department of Primary Industries (formerly Agriculture) have conducted detailed surveys (2002 and 2004) involving face-to-face interviews to capture knowledge from staff within 6 land management Agencies undertaking field-based pest animal duties across the State. These surveys have produced mapping outcomes for 6 pest animal species common throughout NSW.

The NSW DPI surveys included over 120 land managers from 6 Agencies, many of which represent NSW DEC. It was assumed that the outcomes of independent monitoring programs conducted by DEC and other agencies were included in the NSW DPI surveys. Hence, the NSW DPI surveys should reflect the findings of monitoring by other agencies.

NSW Department of Environment and Conservation (formerly NPWS)

NSW DEC has historically conducted a range of wildlife surveys throughout the Reserves and National Parks of NSW. Similarly, various regular monitoring programs exist through the National Parks and Reserves administered by NSW DEC. These represent rather localised datasets in NSW, and in some cases include Reserve areas as well as surrounding private landholdings or Crown Land. Many of the monitoring programs implement conventional monitoring techniques, such as aerial surveys, sand-pad monitoring, and spotlighting (P. Mahon, NSW NPWS, pers. comm., 2006).

NSW DEC often collects, collates and administers data sets for problematic pest species in selected Reserves, such as feral horses within Kosciusko National Park, and Wild Deer within Royal National Park. As a result information often reflects where species are abundant or problematic, and not necessarily where species are having a negligible effect (NSW NPWS website). These and other datasets may be accessible for the purpose of this program, although their currency and suitability need to be confirmed.

NSW DEC also maintain a Wildlife Atlas system for incidental records of species throughout NSW. Wildlife Atlas records are often most abundant in populated regions of the State, and are infrequent in remote areas. These attributes require consideration if Atlas data are to be used to represent species distribution information (P. Mahon, pers. comm., 2006).

Species of importance regarding economic, environmental and social impacts

The following is a list of vertebrate pest species that are of particular significance throughout New South Wales.

- European rabbit
- Red fox
- feral goat
- wild deer
- European starling
- house mouse
- feral livestock
- Indian palm squirrel
- feral pig
- feral cat
- wild dog/dingo
- Indian myna
- hare
- cane toad
- feral horse
- red-eared slider turtle

Species targeted for data collection during recent surveys

NSW DPI have focused on collecting information on:

- European rabbits
- feral pig
- feral goat
- wild deer (6 species)
- wild dog/dingo
- Red fox

NSW DEC have conducted regional and localised surveys (within Reserve areas) associated with control programs for:

- Red fox
- wild dog/dingo
- cane toad
- feral cat
- European rabbit
- feral horse
- feral goat
- wild/feral deer
- feral pig
- rodents (black rats)

Geographic range and scale of data

Data available for NSW can be grouped into: data obtained via state-wide assessment process; and localised datasets. NSW DPI survey data are an example of state-wide data sets, and were obtained throughout NSW and the ACT for 6 species from face-to-face surveys of members from the Rural Lands Protection Boards (RLPB's), National Parks and Wildlife Service, State Forests of NSW, Environment ACT, Sydney Catchment Authority and the Game Council of NSW. The data collection involved qualitative estimates of pest species abundance in a 5km x 5km array encompassing the entire state. Density was ranked as high, medium, low or absent (West and Saunders, 2003).

Localised data sets are those that have been developed, maintained for small areas throughout the State depending on localised needs and priorities. These are predominately related to Reserve Areas (such as National Parks and Reserves).

NSW DEC maintains many localised datasets for a range of pest animal species throughout NSW. An assessment of their suitability is required for the current national invasive species project.

The Wildlife Atlas database may contain individual records (recorded as point locations) of pest species that may be suitable for identifying the locations of low density species (such as red-eared slider turtles) or validating perceptual information (as per NSW DPI survey).

Method of information collection and reporting

Agencies involved

The 2002 survey of pest animals in NSW was conducted by NSW Department of Primary Industries (formerly Agriculture) and involved the collection and collation of spatial data on the distribution and density of 6 primary pest animal species throughout all areas of NSW. The survey involved face to face interviews with land management agencies to capture institutional knowledge (local knowledge) about pest animals. Standardised surveys were conducted across NSW, covering the jurisdiction of several agencies, including Rural Lands Protection Boards (RLPBs), and the National Parks and Wildlife Service, State Forests of NSW, the Sydney Catchment Authority, and Environment ACT.

The survey required the preparation of suitable local area maps prior to the interview process. These consisted of large A0 maps (ranging in scale from 1:250 000 to 1:500000) showing roads, rivers, railways, land tenure and localities

overlaid on high resolution satellite imagery (Landsat 7 ETM). The combination of overlays and the satellite backdrop allowed participants to easily locate features within their area and to describe pest animal and habitat associations as accurately as possible. Satellite imagery was used to pinpoint locations during surveys to collect and present data effectively. Distribution and abundance of pest species was documented using Arcview GIS and high resolution satellite imagery. A 5 x 5 km array (grid) was generated and overlaid on the maps and participants were asked to provide a single density estimate per grid cell. Smaller A3 replica maps were produced to record data.

The distribution and abundance of species was collated using Arcview GIS. outcomes included pest animal distribution maps and recommendations for ongoing monitoring programs and a list of definitions describing abundance to reduce bias when surveying (West and Saunders, 2003).

During 2004, NSW DPI (formerly NSW Agriculture) conducted a repeat survey involving the Rural Lands Protection Boards, National Parks and Wildlife Service, State Forests of NSW (part of DPI), Environment ACT, and Game Council of NSW (NSW DPI unpublished). The 2004 survey replaces information collected during 2002, and projects distribution and density data using the same 5 x 5km array (West and Saunders, 2003). Comparisons between years have been performed.

Period of data collection

In regards to the 2002 and 2004 NSW DPI surveys, the data collection period was undertaken in consultation with multiple agencies to represent annual average density throughout those years consecutively.

There is no single uniform dataset for pest animals in NSW maintained by NSW DEC. Individual surveys providing distribution, density and impact information have historically been collected to suit localised needs, and often as required. Hence, data for a single species across all reserves may have been collected from several independent monitoring programs.

NSW DEC also maintain the Wildlife Atlas database, containing incidental records (and records collected via a range of sampling methods) that records thousands of individual pest animal records collected over 30+ years throughout NSW. Access to the Wildlife Atlas may be obtained to validate qualitative information, or to aid in preparing distribution maps.

Ongoing data collection

Surveys have previously been undertaken to satisfy a range of disease prevention and monitoring needs. There are no known regular state-wide monitoring programs for pest animal populations; however NSW DPI and collaborating agencies recognise the need for ongoing monitoring and evaluation of management performance that such surveys would support.

Monitoring programs conducted by NSW DEC are on-going within many selected Reserve areas throughout NSW. For example, wild dog/dingo monitoring in the

south-east of NSW is an ongoing research and management program providing regular information about wild dogs/dingoes and their density, distribution and impacts (P. Mahon, pers. comm., 2006).

The NSW DEC Wildlife Atlas database provides on-going information on species recorded throughout NSW. This database contains mainly non-pest species information.

Available information

The most recent survey information available for this project was collected during 2004 by NSW DPI (NSW DPI unpublished data). It provides distribution and density information for 6 species in NSW and the ACT, and was collected using a consistent density scaling system and managed within a GIS environment (NSW DPI unpublished). The species included in this survey were feral pigs, feral goats, wild deer, foxes, rabbits and wild dogs/dingoes.

Regional and localised monitoring of pest species is conducted in specific areas under the management of DEC. These data sets should be considered where possible.

Aggregation of existing data

The New South Wales mapping performed by DPI presents a 5 x 5 km array of distribution and density information that can be aggregated to coarser scales as required, eg, to compliment the scale used in Queensland and South Australia. The 2004 data is the most current and accurate data available for 6 species.

NSW DEC information for selected Reserve areas may be aggregated to value-add to information contained within the NSW DPI survey mapping outcomes. This process would simultaneously serve to validate DPI information and provide more spatially accurate data.

Strengths and weaknesses of existing methods and data for State-wide reporting

Strengths

(1) The data that has been collected for NSW covers the entire state and includes the ACT.

(2) The broad-scale data available in NSW provides a guide to the distribution and density of pest animals.

(3) The data provides a platform from which improved information can be developed supporting the monitoring of vertebrate pests on a local, and regional, state and national scale.

(4) The data was collected using a repeatable method that is relatively quick, efficient, and cost-effective, and facilitates a simultaneous survey across the entire state.

(5) Maps produced provide detailed descriptive information of the distribution and abundance of 6 pest species, and can be used to identify spatial and temporal distribution patterns throughout NSW.

(6) The engagement of multiple agencies simultaneously and the estimation of annual average density (not considering seasonality) are considered strengths in the methods adopted in NSW.

(7) The data has been collected from relatively small areas of land which creates maps with fine resolution and more accurate information on distribution and density.

(8) The survey has been repeated (2002 and 2004) and will be repeated again in the future which allows for better estimates and more accurate data to be produced.

(9) NSW DEC datasets are likely to be more spatially and temporally relevant for selected areas than that of the NSW DPI assessment.

Weaknesses

(1) Data that has been collected is subjective and was not collated using intensive field sampling procedures (e.g. the National Monitoring Manuals for pest animals). However, several measures were implemented to reduce perceptual bias within the survey design.

(2) There has been no data collected for any species other than the 6 species mentioned (rabbit, feral pig, fox, wild dog/dingo, wild deer and feral goats).

(3) The data remains largely invalidated and may not be considered sufficiently robust enough to detect minor changes in pest species distribution and density.

(4) There is no strong link between the field collected data and the data presented within the maps, and this remains an assumption of the approach.

(5) Estimated density may reflect a perception of carrying capacity of land and comparisons to past conditions eg. low compared to previous years.

(6) The data from the NSW DPI survey are not readily accessible via a widely accessible information system.

(7) NSW DEC data are not linked with NSW DPI data and mapping outcomes, so changes in Reserve areas are not automatically updated within the DPI maps.

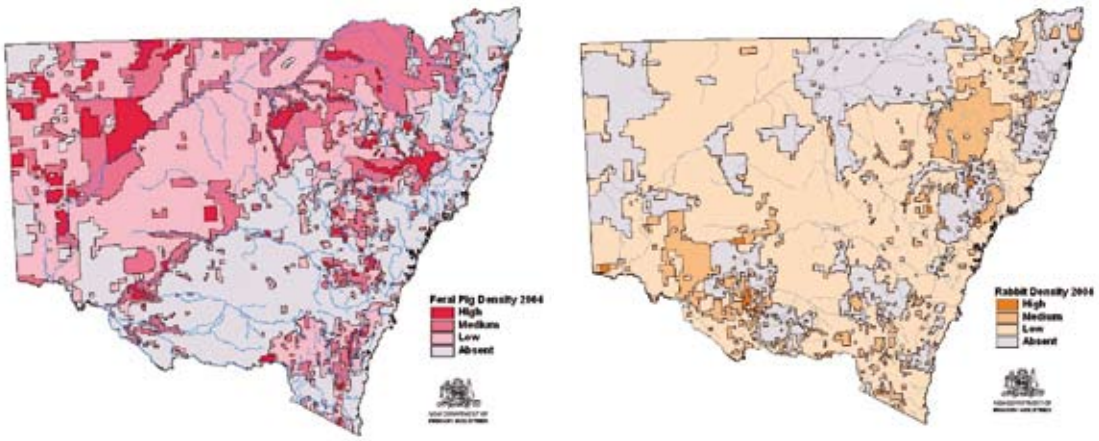
Products of information

Maps and documents

The 2004 NSW DPI survey has produced distribution and density maps for 6 vertebrate pests throughout NSW using a standardised density scaling system. Previous mapping products are available from West and Saunders (2003). An example of the distribution and density maps produced in this report are shown in Figure 1.

Mapping products from NSW DEC National Parks and Reserves were not located during this review process.

Figure 1: Examples of the NSW distribution and density maps produced from the 2002 survey: feral pigs and rabbits. (Source: West and Saunders, 2003).



Reporting frequency

Currently, annual reporting on the distribution and density of pest animals in NSW has not occurred however with increasing focus on pest animals annual or bi-annual reporting may become a regular procedure throughout NSW.

Vertebrate pest monitoring throughout NSW has not been performed on a regular basis. NSW DPI surveys have been undertaken at approximately 3-5 year intervals as required. Previous surveys have produced data sets that have concentrated on 6 species.

NSW DEC do not conduct frequent broad-scale pest animal monitoring programs, but do conduct localised monitoring of pest animal populations (often associated with control activities).

Assumptions of data

The method implemented by NSW DPI relies on the assumption that land-owners and those engaged in pest animal management sufficiently communicate information on the distribution and abundance of pest animals to be reported through the consultation process. It was further assumed that the agencies involved in the survey were well-informed about the abundance of pest animals in the field, and that without verification, that their reports are accurate and true.

The assumptions of information obtained through NSW DEC monitoring activities were not located during this review.

Verification of data

Validation of reported density through intensive sampling using field techniques would test the assumptions of the NSW DPI survey method; however there have been very few attempts to validate the data in this manner.

It is thought that monitoring implemented by NSW DEC within their National Parks and Reserves usually involves conventional survey techniques for which validation is not considered necessary. Where non-conventional methods are used, or methods were used inappropriately, validation of survey outcomes may be necessary prior to using data for generating maps. Furthermore, validation of information may also be needed where distribution and density data is dated.

Data management

A GIS database has been established for NSW DPI monitoring data which can be used for current and future data from surveys. It allows for the production of a range of maps and associated reporting products.

Information from NSW DEC administered land resides in a variety of regional office databases under the management of NSW DEC. Many databases are spatially enabled providing links with mapping products. These should be examined during the national invasive animals program.

Data custodians

NSW DPI are the custodians for data produced in 2002 and 2004 surveys. NSW DEC are the custodians of all information for National Parks and Reserves throughout NSW, including localised survey and monitoring programs, and the Wildlife Atlas database.

Information systems

There are currently no dedicated information systems for vertebrate pest distribution, density and impacts data within NSW. However, recent developments in property-scale information management within NSW DPI may be used for multi-agency pest animal information management throughout NSW.

NSW DPI's commitment to the national BIOSIRT program has seen the recent development and launch of an information system that has potential facilities capable of housing and managing pest animal density and control data as it is collected. Establishing the exact capabilities of this system for NSW and clarifying its potential for multi- agency reporting of pest animal data is required.

2.3 South Australia

Responsibility for management

The Animal and Plant Control Group (APCG) (formally APCC) as an agency of the Department of Water, Land and Biodiversity Conservation (DWLBC), is responsible for collating and analysing data collected from the field by representative regional NRM boards. The APCG conducts research into pest problems, develops state-wide and local policies, and provides technical support to NRM boards. The NRM boards provide some funding for research activities; provide technical advice to land managers, direct regional control programs and conduct enforcement activities (Greg Mutze, pers. comm., 2006, and Department of Environment and Heritage website).

There are eight DWLBC NRM regions throughout the State that are responsible for collecting information for their region. They are also responsible for reporting information to the APCG. Each regional board is responsible for ensuring that the provisions of the *Natural Resource Management Act 2004* are carried out, and enforced within its locality by monitoring and inspecting to determine the distribution and abundance of proclaimed pest animals. The NRM council are responsible for obtaining information from these eight regional boards and reporting to the Minister for the Environment (R. Sinclair, Animal and Plant Control Group, pers. comm. 2006).

The Department of Environment and Heritage (DEH) undertakes pest animal monitoring and management plans for National Parks within South Australia. The DEH is also responsible for 'Operation Bounce Back' which works with local people to reduce the threat that pastoralism has posed to native animals and vegetation (DEH website). National Parks and the Environmental Protection Agency (EPA) are examples of agencies currently functioning within the DEH.

History of pest animal monitoring

Pest animal monitoring in South Australia has historically involved two main agencies, the DEH and the DWLBC.

The main initiative to survey pest animals has resulted in the production of a series of distribution and abundance maps, created by the DWLBC. The data for these maps was collected mainly during 2005, based on surveys of knowledge of authorised officers throughout the state, staff from the APCG, and some external stakeholders (e.g. the Australian Deer Association). The surveys involved a qualitative assessment of pest animal distribution and abundance based on local and regional knowledge (M. Williams, APCG, pers. comm., 2006, and DEH website).

Species of importance regarding economic, environmental and social impacts

Vertebrate pest species that are of particular significance to South Australia include:

- Red fox
- wild dog/dingo
- feral cat
- European rabbit
- feral goat
- feral deer
- feral pig
- feral camel
- European starling

Species targeted for data collection during recent surveys

Species that have been targeted for data collection for broad-scale surveys in South Australia have included:

- feral deer
- feral goat
- Red fox
- feral cat
- feral pig
- European rabbit

Geographic range and scale of data

Distribution and abundance information has been collected and collated at a state-wide scale for deer, cats, foxes, rabbits, pigs and goats (DWLBC website).

Method of information collection and reporting

Agencies involved

The Animal and Plant Control Group (APCG) have previously undertaken surveys to obtain distribution and abundance information of several pest animals. Surveys have involved authorised officers throughout the State, staff of Animal and Plant Control Groups in DWLBC, and external stakeholders such as the Australian Deer Association. This data provides a subjective assessment of the distribution and abundance of pest animals based on local and regional knowledge collected mainly during 2005 (M. Williams, Animal and Plant Control Group, pers. comm. 2006). Maps have been prepared to represent distribution and abundance data using a 0.5 degree (approximately 50km x 50km) grid cell method where the abundance of pest species has been ranked according to the four categories:

- Absent/Rare
- Occasional
- Common
- Abundant

These categories represent abundance within pest species but are not comparable between species (i.e. a species ranked 'abundant' is not necessarily more numerous or causing more damage than a different pest species ranked as 'common'.) Equally, the impact of a population is not always proportional to the ranked category.

The National Parks and EPA divisions of DEH have been conducting aerial surveys and estimate feral goat density annually in the dingo-free rangelands area south of the dingo fence as part of DEH's kangaroo management program. The survey area covers 207,000km² at a sampling intensity of 1.3%. However, this information is not used in feral goat management in SA and the data is held by the DEH.

'Operation Bounce Back'

Feral goat, fox, cat and rabbit numbers have been monitored by the DEH as part of operation Bounce Back program in the Central and Northern Flinders Ranges since the early 1990's. Monitoring for this program involves vehicle transect counts for foxes, cats and rabbits and aerial surveys for feral goats (State of the Environment Report, and supplementary report, 2003).

DEH are also involved in implementing monitoring within areas such as the Innamincka Regional Reserve, Simpson Desert (aerial surveys), and the Gammon Ranges National Park (involving the estimation of feral goat and rabbit density).

Period of data collection

The majority of the data that was used to create the state wide distribution maps for South Australia was collected in 2005 (M. Williams, pers. comm., 2006).

Ongoing data collection

There are no standardised methods for monitoring pest animals in South Australia however with the development of the *NRM Act 2004* and the goals outlined in the State of the Environment Report for South Australia, (2003) indicate there is a progression towards more effective monitoring (DWLBC, *NRM Act* Fact sheet, 2004).

Available information

Currently, there are distribution and abundance maps for 6 pest species in South Australia. These broad-scale distribution and abundance maps are available at the Government of South Australia, Department of Water, Land and Biodiversity Conservation website:
http://www.dwlbc.sa.gov.au/biodiversity/pests/distribution.html#Distribution_Maps_of_Exotic_Animals_in_Sth_Aust

Aggregation of existing data

Data on the distribution and abundance of pest animals in South Australia are available, reported in a 50x50km grid format (DWLBC website).

This scale of data is comparable to other states.

Strengths and Weaknesses of existing methods and data for State-wide reporting

Strengths

(1) Many pest animal species are monitored through broad-scale monitoring in South Australia

(2) The distribution and abundance information reported in the 50x50km grid maps show generalised distributions of species.

Weaknesses

(1) The reporting of distribution and abundance information for pest animals using 50km grid squares presents broad-scale trends in pest populations; and finer-scale data may be unavailable.

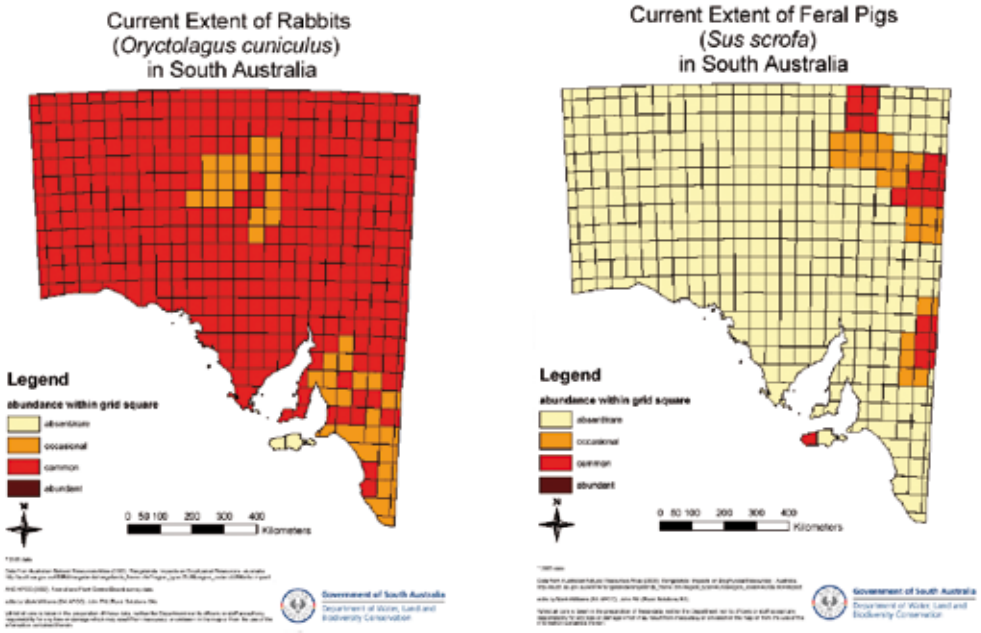
(2) Map data were generated from qualitative estimates from authorised officers and APCG staff on pest animal distribution and abundance. Data have not been validated/ confirmed using alternative techniques.

Products of information

Maps and documents

The DWLBC have produced distribution and abundance maps for deer, goats, foxes, cats, pigs and rabbits throughout South Australia. Examples are shown in Figure 2.

Figure 2: Distribution and abundance maps for feral pigs and rabbits in South Australia according to the DWLBC.



Reporting frequency

Information on the distribution and abundance of pest animals has not previously been reported at regular intervals.

It has not been established whether on-going monitoring and reporting of pest animal distribution and abundance information is current throughout South Australia. However, goals addressing long term monitoring and reporting are proposed in various documents, such as the *NRM Act 2004* and the *SOE report, 2003.*

Assumptions of data

The DWLBC distribution and abundance information data for South Australia assumes:

1) that field officers, land protection officers and local council detect pest animals during their routine land management activities, and communication links are sufficient to effectively transfer information;
2) field captured information is effectively interpreted to prepare accurate distribution and abundance maps; and
3) the distribution and abundance information sufficiently represents variation in the state-distribution of pest animals.

Verification of data

The distribution and abundance information for South Australia consists of qualitative estimates using categories for abundance based on perceptions of APCG staff, authorised officers and external stakeholders.

Verification of qualitative estimates of distribution and abundance information using field sampling at selected areas has not been performed.

Data management

Pest 2000

The APCG developed PEST 2000, a management system that contains property data that comprises pest animal assessment data ranked against a subjective scale at 50 x 50 km grid cells. It was designed to record actions (eg. management activities, and property inspections) rather than raw field data (Vertebrate Pest Indicator Submission, 2006).

Information contained in Pest 2000 has not been frequently updated, and large gaps in datasets exist as some NRM boards have failed to supply information. Pest 2000 produces reports containing information that is not spatially referenced. Pest 2000 is currently a Microsoft Access database that, if linked with PIRSA's PIMS, may be able to produce spatial map outputs (M. Williams, pers comm., 2006).

Data custodians

The DWLBC are the custodians of data that has been supplied from the NRM boards to the APCG. However, each NRM board is a separate statutory body that functions individually and there are no formal agreements or legislation to ensure data is shared (R. Sinclair, pers. comm., 2006).

The DEH are custodians of information regarding operation Bounce-Back for foxes, rabbits and cats. The DEH also controls aerial survey data collected for goats since 1989.

The Animal and Plant Control Group (APCG) are custodians of information on feral goat and rabbit densities from within the Gammon Ranges National Park.

Information systems

Primary Industries Management System

The Primary Industries Information Management System (PIMS) has been developing since 2001. PIMS is owned by PIRSA, and has been developed in consultation with Department of Agriculture, Western Australia. It is a web-based program containing up-to-date information on public and private land holdings. PIMS is built using ArcIMS ESRI software with maps delivered using browsers. It is a generic database that is table driven with mapping outputs. The spatial property component is integrated with Lands Department property information. Animal health officers use palm pilots with registration extracts from PIMS that are taken into the field. PIMS does not currently contain pest animal information, but maintains regulatory information regarding premises (M. Williams, pers. comm., 2006).

2.4 Australian Capital Territory

Responsibility for management

Primary responsibility for implementing government policy on vertebrate pest management lies with Environment ACT. It administers relevant legislation, undertakes extension and education functions and maintains liaison and collaborative links with other government agencies and institutions, and community based organisations. Relevant advisory committees such as the Natural Resource Management Advisory Committee, the Flora and Fauna Committee and the Animal Welfare Advisory Committee contribute to the development and monitoring of planning and management programs. Environment ACT also undertakes vertebrate pest management directly as a public land manager and coordinates vertebrate pest management as a function of land management throughout the Territory.

Responsibility and authority for on-ground management is shared between Government land managers and the rural community. The ACT Conservation and Land Management (CALM) group interacts with Canberra Urban Parks and Places and the rural community when a coordinated approach to vertebrate pest management issues is required. The *Pest Plants and Animals Act* 2005 lists declared pest animals in the ACT. Three notifiable species/genera are listed: Red Imported Fire Ant (*Solenopsis invicta*), Red-eared Slider Turtles (*Trachemys* spp.) and Red-whiskered bulbul (*Pycnonotus jocosus*). Under the Act Pest animal management plans may be prepared for declared pest animals, and these plans may include the requirement for reporting and recording of pest animal presence and/or impact (N. Webb, Environment ACT, pers. comm., 2006).

History of pest animal monitoring

A number of pest monitoring programs have been conducted by Environment ACT. For example, the abundance of rabbits, foxes, cats, and red-necked wallabies has been monitored using spotlight transect counts in five valleys within Namadgi National Park (NNP) since 1993 and in Tidbinbilla Nature Reserve since 1976. Googong Foreshores has been surveyed similarly since 1980, with eastern grey kangaroos as an additional species counted there.

Since 1985 there have also been annual surveys and coordinated control programs for feral pigs throughout Namadgi National Park (Hone, J, 2002). This is an ongoing activity, and is complemented by density/damage research by Prof. Jim Hone of the Institute for Applied Ecology at the University of Canberra. Prof Hone's monitoring indexes pig density and damage.

Sand-pad monitoring of wild dog activity within Namadgi National Park is also conducted in selected areas as part of two NSW/ACT Wild Dog collaborative projects (D. Fletcher, Environment ACT, pers. comm. 2006).

ACT Government maintains a Vertebrate Atlas System for incidental records of wildlife (excluding birds) in the ACT region. The presence of pest species may be obtained from the Atlas. The Vertebrate Pest officer within CALM maintains records

of pest species reported by Environment ACT staff and members of the public. The Canberra Ornithologists Group (COG) have also developed and maintained bird species records over many decades. Pest bird records may be obtained from this database. Pest bird distribution information may also be obtained from Chris Tidemann, Australian National University, Canberra ACT 2601, chris.tidemann@anu.deu.au (http://sres.anu.edu.au/associated/myna/spreading.html), or direct from Birds Australia (See http://www.birdsaustralia.com.au/). (D. Fletcher, pers. comm., 2006).

NSW DPI (formerly Agriculture) have conducted two broad-scale assessments throughout NSW incorporating the ACT region. These have involved liaison with ACT Government representatives and qualitative assessments of pest animal density (West and Saunders, 2003). It is assumed that outcomes from monitoring programs within the ACT were considered during this assessment process. These form the main whole-of-territory pest abundance datasets for the ACT region, and include 6 main pest animal species of the region, but are of less assistance in making management decisions than the quantitative long term records from the monitoring sites mentioned above.

There is limited monitoring of pest animals within the urban protected areas in the ACT (namely Parks, Gardens and Reserves).

Species of importance regarding economic, environmental, and social impacts

The pest animal species that have particular significance in the ACT are:

- European rabbit
- Red fox
- feral goat
- red-eared slider turtle
- wild deer
- feral cat
- feral horse
- wild dog/dingo
- feral pig
- introduced birds (mynas and starlings)
- eastern grey kangaroo

The eastern grey kangaroo has the highest reported densities in isolated grassland areas in Australia within the ACT. They are considered important because they compete with grazing and can be involved in road collisions (ACT Commissioner for the Environment, State of the Environment Report, 2003). Wild deer are a declared pest in the ACT but the impacts are unknown at this stage.

Species targeted for data collection during recent surveys

In the ACT, the species that have previously been or are currently being monitored at are:

- feral pig
- European rabbit
- Red fox
- feral goat
- feral horse
- Indian Myna
- kangaroo
- wild deer
- wild dog/ dingo

Geographic range and scale of data

Monitoring data for feral pigs, rabbits, wild dogs /dingoes, foxes, feral goats, deer, kangaroos and feral horses is limited to selected areas of the ACT region (predominantly National Parks and selected Reserve areas).

Avian fauna records include point location information throughout much of the Territory.

Regional data sets for 6 pest species (feral pigs, feral goats, wild deer, foxes, rabbits and dingoes/wild dogs) containing qualitative estimates of density (reported using 5km grid array) are obtainable from the NSW DPI surveys (2002 and 2004).

The ACT poses a unique pest management scenario, in that over half of the Territory is protected within National Parks and Reserves, and most of the remainder is classified urban residential land. These facts need to be considered when designing regional monitoring programs throughout the Territory.

Method of information collection and reporting

Agencies involved

Environment ACT

Monitoring and control in the ACT has primarily been performed by Environment ACT. Dedicated monitoring programs have been performed within selected areas (mainly protected land) using various conventional monitoring techniques (including spotlighting, sand-pads, and aerial surveys). Limited monitoring of pest animals has been undertaken within the urban residential/rural districts of the ACT.

Feral pig monitoring within selected areas of NNP has also been conducted by the University of Canberra using damage plots over several years. Damage plots indicate the relationship between estimated density and damage attributed to feral pigs. Inferences about broad-scale impacts of feral pigs are proposed.

The State of the Environment Report for the ACT region (2003), proposes monitoring goals which include:

Foxes – Proposed further analysis of monitoring information;

Deer – Sightings reported to officers and continual monitoring;

Rabbits – Analysis of previous monitoring data, continued control and monitoring;

Pigs – Proposed monitoring of effected plant communities proposed;

Horses – Ongoing monitoring of horse activity in NNP is proposed;

Goats – Radio tracking information within NNP has been examined, monitoring continues; and

Wild Dogs/dingoes – monitoring has been considered as part of a NSW/ ACT collaborative program, using sand-pad monitoring along transects. Intensive monitoring by dog trappers, radio telemetry and associated activities continues.

NSW Department of Environment and Conservation

Collaborative monitoring and control programs between NSW and the ACT have largely involved: feral pig surveys in protected areas, sand-pads and fixed wing radio telemetry of wild dogs/dingoes in protected areas (and surrounding landscapes).

NSW Department of Primary Industries

Qualitative estimates of pest animal density have been obtained through surveys involving ACT representatives (capturing local knowledge) to provide descriptive maps of major pest animals in the ACT and surrounding NSW.

Period of data collection

Monitoring of pest animals in the ACT has varied with species, and region. The oldest data set has run for thirty years (D. Fletcher, pers. comm., 2006).

Ongoing data collection

The ACT has many strategies in place to collect data on pest species in the future. The following are policies proposed by Environment ACT for the monitoring and assessment of vertebrate pests:

- Having an annual program of survey/monitoring of the distribution and abundance of vertebrate pest species. The program builds upon existing work
- A database of information obtained will be developed and maintained. It will include data that becomes available from a range of sources
- Vertebrate pest management programs that routinely incorporate an operational monitoring component and a performance monitoring component. The advantages of a standardised design format will be explored.

In addition to these goals, current monitoring programs are expected to continue where possible (Environment ACT Vertebrate Pest Management Strategy, 2002).

Available information

Various species-specific monitoring initiatives have produced data sets for regions of the ACT. However, the most recent broad-scale data available for the ACT is that derived from the NSW DPI 2002 and 2004 pest animal surveys where the ACT was mapped accordingly.

Apart from the surveys of NSW DPI, broad-scale data covering the entire ACT region was not located during research for this report. Data available within the ACT have primarily been collected within selected areas (such as NNP). This is considered valuable data for the ACT region.

Avian fauna records from Atlas and Birds Australia databases may provide information from all regions/districts of the ACT, but its currency may require examination.

Aggregation of existing data

Data for the ACT require careful consideration if used in the national invasive animals program.

NSW DPI mapping information was obtained using a 5 x 5 km grid array to represent the distribution and density of selected pest animal species. This data may be easily aggregated for the purpose of national mapping but is considered of low reliability by local experts in the ACT (D. Fletcher, pers. comm., 2006).

Strengths and weaknesses of existing methods and data for State-wide reporting

Strengths

(1) Data available for Namadgi National Park covers a large proportion of the ACT.

(2) Many datasets that have been collected within National Parks are long term, continuous data.

(3) Several species considered pest animals in the ACT have had some monitoring performed, i.e. some data are available for almost all pest species.

(4) The NSW DPI survey data can be used as a coarse but informative guide to 6 species in the ACT region.

(5) Many conventional monitoring techniques have been employed to obtain data on pest species, namely sad-pad monitoring, spotlight counts etc.

(6) Several agencies and community groups maintain databases that may potentially contain information for this program (namely Environment ACT - Vertebrate Atlas, Birds Australia, Canberra Ornithologists Group and the University of Canberra).

(7) Some localised datasets are of high quality and may serve as benchmarks for density-damage information.

(8) NSW DEC may contain complementary data for pest species on several ACT/ NSW borders.

Weaknesses

(1) The number of species that have been monitored across the entire Territory is low.

(2) The urban residential area of the ACT has not been addressed for monitoring.

(3) Collaborative monitoring programs between ACT Government Agencies (namely former ACT Forests and Environment ACT) have been infrequent, leading to gaps in knowledge. Recent merging of agencies has lead to confusion about responsibility for on-going monitoring.

(4) Large geographic regions of the ACT contain little quantitative information, eg the mountain forests.

Products of information

Maps and documents

Distribution and density maps for the ACT are available from the outcomes of the NSW DPI survey initiatives, and pest animal survey in 2002 and 2004. Aside from this, Environment ACT has produced the ACT Vertebrate Pest Management Strategy 2002 which includes recommendations and future goals. Additionally, there have been smaller scale reports produced focusing on regional areas such as Namadgi National Park, however some datasets require further analysis.

Reporting frequency

There is annual reporting of vertebrate pest control however the format of this reporting is unknown.

Assumptions of data

The method of data collection implemented in NSW (that includes the ACT) by NSW DPI relies on the assumption that land-owners and those engaged in pest animal management sufficiently communicate information on the distribution and abundance of pest animals to be reported through the consultation process. It was further assumed that the agencies involved in the survey were well-informed about the abundance of pest animals in the field, and that without verification, that their reports are accurate and true.

Verification of data

Many of the pest animal surveys in the ACT have been conducted using conventional techniques that require little validation. The data sets from these surveys provide localised density indexes in habitats where the target species are typically of interest, eg. rabbits in grassy areas. In many cases it is reasonable to extrapolate or interpolate to other similar habitats in the region, which are under comparable management influences.

There have been no attempts to verify the qualitative estimates of density obtained from the NSW DPI surveys.

Data custodians

Custodians for pest animal data sets in the ACT include CALM (Environment ACT), Birds Australia, Canberra Ornithologists Group, the Australian National University (Chris Tidemann for avian species only), the University of Canberra (feral pigs only), and NSW DPI (for 2002 and 2004 pest animal survey data only).

2.5 Queensland

Responsibility for management

The Department of Natural Resources, Mines, and Water (DNRMW) is the primary Government Agency responsible for the management of introduced mammals, reptiles and amphibians, as well as dingoes, locusts and crazy ants in Queensland (DNRMW website).

The DNRMW works closely with local governments and other key stakeholders to minimise the impacts of pest animals. Other stakeholders involved in managing pest animal problems include:

Department of Primary Industries and Fisheries (DPI&F);

Environmental Protection Agency (EPA);

Queensland Parks and Wildlife Service (QPWS);

Lands Protection Council;

Local Governments;

Regional and community groups; and Landholders (legally responsible for control on their land).

(source: Queensland Pest Animal Strategy, 2002- 2006)

History of pest animal monitoring

Pest animal monitoring in Queensland has historically consisted of State-based attempts to capture distribution and density information, as well as regional initiatives that have targeted selected areas (Vertebrate Pest Indicator Submission, 2006).

The State-wide initiatives have included the development of the Annual Pest Assessment (APA) now referred to as the Annual Pest Distribution Survey (APDS) coordinated by the DNRMW, encompassing Land Protection Officers and information on pest animal and weed presence and density gathered from Local Councils (where available).

The DNRMW produce a comprehensive series of pest distribution maps from the results of their APDS. These are available as state and regional maps. The results from these surveys are reported from 2003 to 2005 however similar data have previously been collected. The APDS records are maintained by Pest Information (Management project of land protection).

There have been regional initiatives to monitor pest animals in Queensland that include monitoring throughout Queensland by Australian farmers (in 1999); and a survey by the World Wildlife Fund in conjunction with Australian Bureau of Statistics (ABS) in 2001 (Pest Strategies Information Sheet, 2005).

Species of importance regarding economic, environmental and social impacts

In Queensland, pest species are divided up into 3 classes (two of which are currently used) under the Land Protection (Pest and Stock Route Management) Act 2002. These animals are targeted for control as they represent a threat to primary industries, natural resources and the environment. These classes include:

Class 1 Pests – Pests not commonly present in Queensland, and if introduced would cause an adverse economic, environmental or social impact. It is intended that Class 1 pests detected in Queensland are eradicated. Landowners must take reasonable steps to keep land free of Class 1 pests. Class 1 pests in Queensland include:

- crazy ants
- all mammals, reptiles and amphibians except class 2 declared pest animals, mammals, reptiles and amphibians indigenous to Australia, including marine mammals and 32 non declared animals

Class 2 pests – Pests established in Queensland and have, or could have, a substantial adverse economic, environmental or social impact. The management of these pests requires coordination and they are subject to control led by local government, community and/or landowners. Landowners must take reasonable steps to keep land free of Class 2 pests.

Class 2 vertebrate pests in Queensland include:

- feral cat
- feral goat
- feral pig
- Red fox
- European rabbit
- wild dog/dingo

Class 3 Pests – A class 3 pest is established in Queensland and has, or could have, an adverse economic, environmental or social impact. Landholders are not required to control Class 3 pests unless their land is adjacent to an environmentally significant area. There are currently no animals declared as Class 3 (DNRMW website).

In addition to these 3 Classes, the Land Protection (Pest and Stock Route Management) Act 2002 (DNRMW website) includes 32 animals specifically categorised as "non-declared" species. However, several of these species are considered pest species in other States of Australia.

'Non-declared' animals include: mammals commonly kept for commercial or social benefit; and non-native mammals, reptiles or amphibians that are widespread but have minimal negative commercial, environmental or social impacts; and/or there are no cost-effective broad scale control measures available. Non-declared animals in Queensland under this Act can be found at:

http://www.nrm.qld.gov.au/pests/pest_animals/non_declared/index.html

Species targeted for data collection during recent surveys

The following vertebrate pest species have been included as the core species in the APDS throughout Queensland:

- feral cat
- feral goat
- feral pig
- Blackbuck antelope
- Water buffalo
- Red fox
- European rabbit
- wild dog/dingo
- Red-eared slider turtles
- Chital deer

Other pests recommended by the annual pest survey reference group, including Class 3 pest plants, are mapped as necessary. In total, 60 species of animal and plant are included in the 2005 distribution maps on the Queensland Government website which includes 10 species of vertebrate pest. Blackbuck antelope, chital deer, red-eared slider turtle, and water buffalo were also included in the APDS in 2005.

Geographic range and scale of data

The data obtained in the APDS covers the entire state. The APDS is reported using a 0.5° grid framework (approx. 50 km x 50 km) laid over the west and northern parts of Queensland. Smaller 0.125° cells (approx. 16.67 km x 16.67 km) have been used along the east coast of the State since 2004 (DNRMW website).

Method of information collection and reporting

Pest infestation data are very important for making decisions about pest management issues; however, undertaking conventional on-ground surveying of all major pest plant and pest animal species throughout Queensland each year is not feasible.

The NRM produce a series of pest distribution maps on an annual basis from the results of the APDS. These are reported as state and regional maps (North, Central West, South West and South East). The annual pest distribution survey includes more than 40 pest plant and pest animal species in Queensland (DNRMW website).

Information for each pest is gathered through regional workshops, where participants include local government and NRM officers, and other people with knowledge of local pest locations. During these workshops, species are assessed using three criteria (occurrence, distribution and density). These are defined herein (obtained from NRM) as:

(1) Species occurrence—present/absent/unknown

It is essential to know if a pest is present or absent in each cell. If the survey participants cannot say with a very high degree of accuracy whether the pest is present or absent, the cell is flagged as unknown. This criterion has the highest level of accuracy.

(2) Distribution—localised/widespread

Once it has been established that a pest is present within a cell, it is necessary to indicate how much of the cell contains infestations of the species. Infestations that occur across more than half the cell in any density are considered widespread, while those that cover less than half the cell are considered localised. While distribution gives us a useful indication of the size of pest infestations within grid cells, its accuracy should not be relied on too heavily. Reasons for this include:

- Survey participants may have differing perceptions of distribution measures;
- Survey participants may lack knowledge of particular species; and
- It is difficult to accurately assess large areas of remote and impenetrable land.

This criterion has a lower level of accuracy than 'occurrence', and should only be used as a guide when making state-wide comparisons.

(3) Density—occasional/common/abundant

Density refers to how thick or sparse pest infestations are. The following three descriptors are used:

Occasional: single plants/animals spaced apart at wide intervals

Common: a middle measure between occasional and abundant

Abundant: infestations that have reached their full potential and provide little opportunity for additional plants/animals to survive in that area.

This criterion has a lower level of accuracy than 'distribution'. Density can be considered more accurate at the shire level than at the state level and should only be used as a guide when making state-wide comparisons.

The APDS is reported in using a 0.5° grid framework (approx. 50 km x 50 km) laid over a map of Queensland. This enables the distribution and density of pest species to be rated on a cell-by-cell basis across the entire State. Smaller cells are used to report the distribution and density of pest animals along the east coast of Queensland from Cook Shire to the Queensland/New South Wales boundary where 0.125° cells (approx. 16.67 km x 16.67 km) are applied. Higher population density and improved reporting capacity are reasons for this scale throughout this area (Cross, J, 2005).

The DNRMW are attempting to create secondary products from the data gathered in the survey, addressing trends in density, and movement information.

Agencies involved

Surveys are completed by local government and NRM&W officers, and other people with knowledge of local pest locations. There is a list of local councils that have provided the information for the surveys on the Queensland Government, DNRMW website.

Period of data collection

In Queensland, the APDS is performed annually to maintain up-to-date records on the distribution and density of pest species.

Ongoing data collection

According to the DNRMW, the APDS will continue to supply accurate and informative information for pests (weeds and pest animals) throughout Queensland in an on-going capacity. On-going annual data from this program could be considered for the development and maintenance of national mapping products and outputs.

DNRMW indicate that there may be opportunity to enhance the distribution and density maps prepared throughout Queensland by improving the information base used to estimate the distribution, abundance and impact of particular pest species. Increasing the monitoring and mapping of pest species, as well as promoting compatible spatial and temporal data collection systems (particularly between agencies), will serve to improve spatial data sets on pest animals.

Available information

Queensland Government maintain annually updated spatial maps at a scale of 0.5º (approximately 50km x 50km grid squares) and 0.125º (approximately 17km x 17km grid squares) for feral cats, foxes, feral goats, rabbits, feral pigs, wild dogs/dingoes, and feral deer.

For further information about either the APDS, these data sets or their management see the Vertebrate Pest Manual (2005) – A guide to pest animal management in Queensland, and the Queensland Pest Animal Strategy (2002-2006) that are available from the Natural Resources and Mines sector of the Queensland Government.

Aggregation of existing data

The APDS assesses the distribution and density of pest animals across the entire State annually. To achieve this, reporting at a 0.5º scale has been selected for its feasibility and cost-effectiveness.

These data represent the minimum scale of information. Aggregation of data has not been undertaken to produce these map products. The Officers involved in the APDS have contributed to APDS assessment through either local pest data collection of their own systems or field operation experience.

Strengths and weaknesses of existing methods and data for State-wide reporting

Strengths

(1) The monitoring and management system applied in Queensland for vertebrate pests is, at this stage the most established in terms of frequency and extent in Australia. There is a schedule for future investigations that could produce data showing trends over a certain number of years.

(2) The data also covers the entire state and the method for data collection is cost and time efficient.

(3) The surveys that form the basis of the data available for Queensland are collected annually.

(4) The surveys have included multiple land protection officers and land managers whose knowledge and expertise are invaluable.

(5) The categories for describing variation in the spatial distribution (widespread, localised) and density (abundant, common, and occasional) provide more descriptive mapping information than other data available in Australia.

Weaknesses

(1) The methods used for Queensland involve collecting data over a large spatial scale (50km x 50 km) which results in generalised information and data outputs. Variation in the distribution and density of pest animals within any selected 50km cell are not captured/represented in any means.

(2) The surveys provide subjective estimates of density from informed field personnel that reflect personal perception of distribution and density.

(3) Where robust field collected data form the basis of the survey results, it is unclear whether this has occurred.

(4) Field validation of APDS density estimates have not been performed.

(5) The scale of the surveys may not be sufficient to detect or report minor changes in populations that may be associated with management actions, such as control.

(6) Several pest species in Queensland are not mapped using the APDS system. However, species included in APDS are reviewed and recommended by the annual pest survey reference group every year.

Products of information

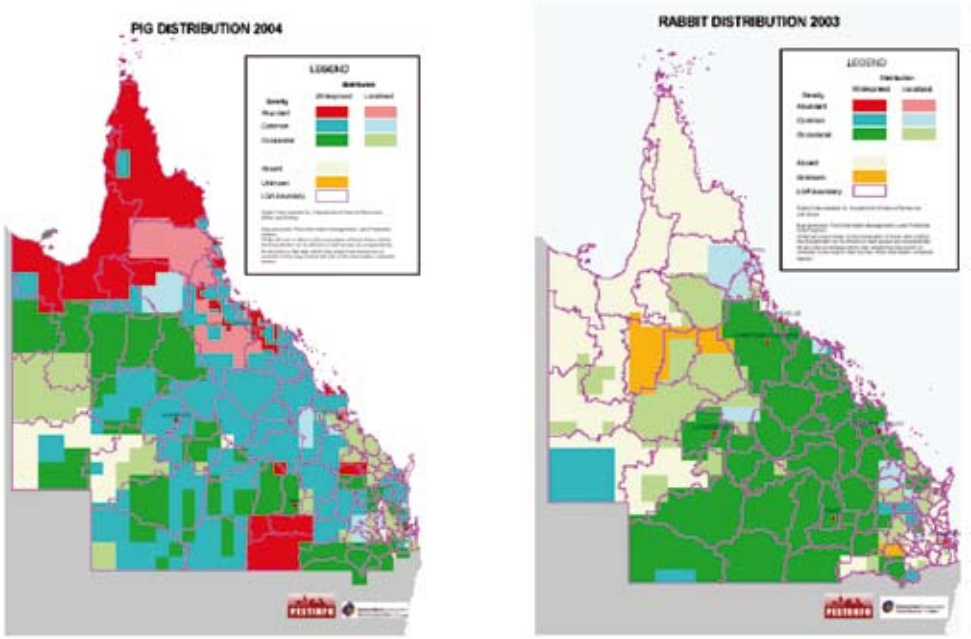
Maps and documents

Queensland has produced a high number of animal distribution and density maps for many vertebrate pest species which are available via:

http://www.nrm.qld.gov.au/pests/maps/pest_distribution/distribution_maps.htm

Examples of these are shown in Figure 3.

Figure 3: Mapping products from the APDS for feral pigs (2004) and rabbits (2003) from the DNRMW (Source: DNRMW website).



Reporting frequency

The pest survey in Queensland is performed annually and therefore results are released on the DNRMW web site once a year.

Assumptions of data

The APDS relies on:

1) the distribution and abundance of pest animals to be detected by field officers, land protection officers and local council during their land management activities;
2) effective communication of information to those individuals reporting within the APDS;
3) effective interpretation of that information to prepare the APDS survey maps; and
4) consistent understanding of the mapping categories that reflect variation in the state-distribution of species.

The APDS therefore assumes:

- The communication links are sufficient to transfer information effectively;
- Changes in populations are detected, reported and recorded accurately;
- The mapping data effectively capture, store and represent variation in the state-distribution of pest animals; and
- The methods are robust and sensitive enough to determine variation in populations in response to control, climatic conditions, resource and habitat changes, and other variables.

Verification of data

Once APDS is performed, the data is examined and verified by a group of species experts throughout the state. The fact that the survey is performed annually also allows some trends or discrepancies to be detected if they occur.

Data management

Data obtained through the APDS are managed within PestInfo.

Data custodians

The Department of Natural Resources, Mines and Water (DNRMW) are custodians for the data obtained from Queensland through the Annual Pest Distribution Surveys.

Information systems

PestInfo (Queensland Pest Data Management System) is a dedicated geographic information system designed for mapping the distribution and density of weeds and pest animals in Queensland (Vertebrate Pest Indicator Submission, 2006).

The PestInfo system is an integrated application that incorporates the spatial data processing capabilities of Intergraph GeoMedia Object, a desktop geographic information system, and the attribute data management strengths of Microsoft Access, a relational database.

PestInfo is managed by the DNRMW who are the custodian organisation. PestInfo is a map-based information system, which records and manages the distribution of weeds and pest animals. PestInfo has a wide range of user-base and has been designed to meet these diverse needs and characteristics. The users group includes a large number of Local Governments, specialty groups, other State Government Departments and interstate Governments and community groups. PestInfo is currently in its 4th release. The data has been collected through 3 methods in PestInfo system: approximate property flagging method, hand-digitising method, and GPS survey method. Among the 3 methods, GPS survey method is the most accurate method to record pest infestation. These data are then used to produce cartographic-quality maps and reports that enable users to analyse potential impacts and determine appropriate pest management strategies.

The technological significance of PestInfo is that it has combined the spatial information and non-spatial attributes into one single Microsoft Access database. Attributes data are entered using intuitive Visual Basic forms that additionally serve to integrate all system components. PestInfo also features a user-friendly Windows interface that includes familiar components such as pull-down menus and tool bars. This makes PestInfo easy to use for anyone familiar with the Windows environment. A density scale has been developed by the State Land Pest Management Project and Pest Information management unit to ensure the consistency of density of all data collected through the PestInfo system.

According to the DNRMW, in the short term, the agency is placing emphasis on continually developing the functions and features of PestInfo, based on client feedback and emerging business directions. The transfer of data from the local

level to the state is earmarked for improvement, for example possibly using file transfer protocol (FTP) in the short term, and longer term using web-based facilities to provide real-time data transfer. Looking to the future, DNRMW is confident that PestInfo's open technology will ensure that it continues to meet Queensland's evolving needs for strategic pest management.

2.6 Western Australia

Responsibility for management

Responsibility for the management and compliance of declared animal pests resides with the Department of Agriculture and Food (DAFWA) and the Department of Environment and Conservation (DEC, formerly CALM). DAFWA aims to minimise the effect of vertebrate pests in Western Australia by preventing the entry of new pest species to the State, controlling existing populations, minimising the impact of widespread pests, raising awareness of the problems and researching the solutions for vertebrate pests. The Department of Environment and Conservation (DEC) is part of a greater conservation community and has distinct State Government responsibilities for implementing Government policy. DEC have responsibility for conserving the State's rich diversity of native plants, animals and natural ecosystems, and many of its unique landscapes. DEC manages more than 24 million hectares, including more than 9 percent of Western Australia's land area: its national parks, marine parks, conservation parks, regional parks, State forests and timber reserves, nature reserves, and marine nature reserves (CALM Nature Base website). DEC also has on-ground management responsibility for pest animal and weed control on unallocated Crown Land and unmanaged reserves across the State (outside the Perth metropolitan area and townsites). These areas cover 89 million hectares (John Asher, pers comm., 2006).

History of pest animal monitoring

Information on pest animals in Western Australia has been established through many differing methods. At a state level, Long (1988) compiled a comprehensive account of the introduced birds and mammals in Western Australia including their distributions.

More recently, data on the distribution and abundance of a range of pest animals have been obtained through a multi-agency survey for the state of Western Australia. Institutional knowledge from DAFWA and DEC was used to acquire information on pest animal abundance, collected between November 2002 and November 2003. Information represents a small temporal snapshot of the distribution and abundance of pest animals. Outcomes are presented within the Woolnough *et al*. (2005) report entitled *'Distribution and Abundance of Pest Animals in Western Australia: A survey of Institutional Knowledge'.*

Along with the initiatives outlined above, ongoing aerial surveys are conducted to determine the abundance of large mammals in the rangelands of Western Australia (Southwell & Pickles, 1993). Mail out and aerial surveys have been used by the Agriculture Protection Board in the past to ascertain the impact and abundance of feral pigs (Marscak, 1989). Broad-scale aerial surveys have been conducted annually by DEC (and the Commonwealth Department of Environment

and Heritage) since 1983, to determine quotas for the kangaroo industry. These surveys focus primarily on kangaroos but include other large herbivores such as feral goats, feral donkeys and feral horses. Other species-specific aerial surveys have been conducted for feral goats, feral donkeys and feral camels, but these have generally been short-lived programs.

DEC's Western Shield program also incorporates intensive native fauna response monitoring following fox baiting and has been in operation since 1996 (P. Orell, Zoologist, Western Shield, pers. comm., 2006). Both fox (DEC) and wild dog (DAFWA) baiting programs monitor aerial bait-drop with GPS systems to determine the spatial coverage and intensity of baiting campaigns.

Species of importance regarding economic, environmental and social impacts

Vertebrate pest animals that are of particular significance to Western Australia include:

- European starling
- feral goat
- feral deer
- wild dog/ dingo
- feral pig
- feral horse*
- feral cattle*
- rainbow lorikeet†
- Red fox
- European rabbit
- feral camel*
- feral donkey*
- feral cat
- feral sheep*
- cane toad

*Rangeland specific species.

†Perth metropolitan region and surrounds

Species targeted for data collection during recent surveys

For the recent state- wide surveys in Western Australia, the state was divided into two regions: the agricultural region; and the rangelands/ pastoral region. Species considered in the 2002-03 survey within both the agricultural region the pastoral region included:

- feral pig
- feral deer
- feral goat
- wild dog/ dingo

Additional species considered in the rangelands/pastoral region included:

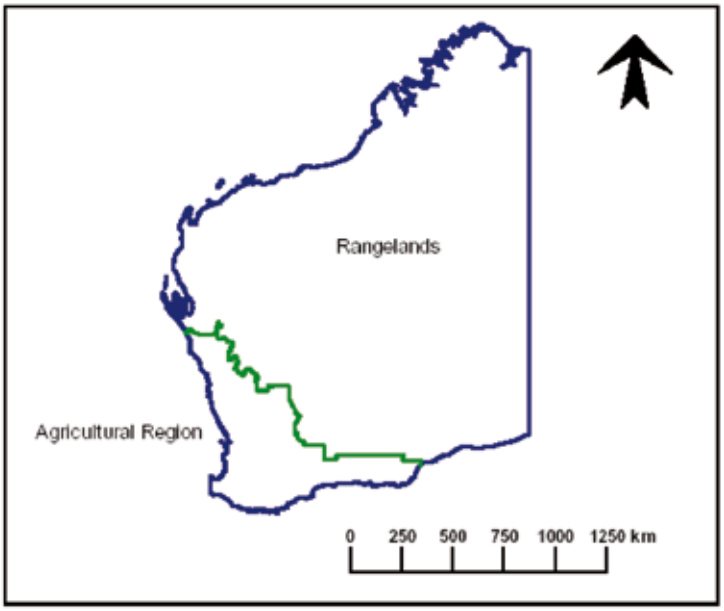
- feral donkey
- feral camel
- feral horse
- feral sheep
- feral cattle

Species such as rabbits, foxes and feral cats were not included in the broad mapping exercise because of their widespread distribution (Woolnough *et al*, 2005).

Geographic range and scale of data

Spatial data describing the distribution and abundance of pest animals have been collected on a property basis. In all, details of over 40,000 land parcels were recorded across most land tenures greater than 10 ha in area. For the purposes of maintaining landholder privacy, publicly released map outcomes were deconstructed into 10x10 km grid cells. The data was collected from two separate regions (rangelands/ pastoral and agricultural) then combined to produce a state-wide representation of the distribution and abundance of pest animals. The agricultural region was surveyed during early 2003 and the rangelands (or pastoral region) was surveyed during late 2003. The agricultural and pastoral zones differ greatly in size (figure 4). Although the surveying was carried out over a period of one year, the seasonal differences between each survey region due to time of sampling may cause some inconsistencies for the mapping of species distribution (Woolnough *et al*, 2005). The data were not ground truthed to verify the precision of the information.

Figure 4: Map showing the Rangelands and Pastoral zones of Western Australia (Source: Woolnough *et al*, 2005).



Method of information collection and reporting

Agencies involved

Biosecurity staff from DAFWA and staff from DEC were involved in a survey to determine the distribution and abundance of pest animals in a cost-effective manner. After conducting a preliminary investigation, an approach similar to West and Saunders (2003) was employed with slight modification to the Western Australian environment. Importantly, the definitions for abundance refined by West and Saunders (2003) were used unchanged to allow for local, regional and state comparisons of information (see Woolnough *et al*, West and Saunders 2004). Sampling was undertaken over a 13 month period and included 104 face-to-face surveys with staff from DAFWA and DEC. Data from the agricultural region was collected from November to July 2002 and data from the pastoral region was collected from August to November 2003.

Period of data collection

Data provided from the DAFWA and CALM survey was collected between 2002 and 2003. This survey provided the first state-wide dataset providing an informative and representative snapshot of the distribution and abundance of pest species throughout Western Australia.

Ongoing data collection

Woolnough *et al*. (2005) suggested that repeating the state-wide surveys at regular intervals (approximately every 5 years) would provide valuable data on temporal changes in the distribution and abundance of pest animals.

Currently, field officers collect information on pest animals while conducting property inspections. Records of the presence/ absence or abundance of declared pest species are obtained and added to an information database maintained by DAFWA. Inspections are targeted at properties known to exhibit pest animal problems primarily in the Agricultural zone of Western Australia. Thus, information at and around pest animal problem areas are maintained at a higher frequency than areas where the problems associated with pest animals are less intense (P. Thompson, pers. comm., 2006). Coverage of all areas in a systematic yet strategic manner is required to detect, report, and respond to new incursions and changes in pest animal distribution and abundance.

Available information

Distribution and abundance maps are available for several species in Western Australia (see Woolnough *et al*. 2005, or www.agric.wa.gov.au). The distribution and abundance information is available via DAFWA for feral pigs, feral goats, feral deer, wild dogs, feral donkeys, feral camels, feral horses and feral livestock.

Aggregation of existing data

Data on pest species was collected at a property-scale throughout Western Australia, although property size varies considerably throughout the State. Due to privacy issues, property-scale information were deconstructed into 10x10km² cells to obscure property boundaries and facilitate comparisons between surveys (Woolnough *et al*, 2005).

Strengths and weaknesses of existing methods and data for State-wide reporting

Strengths

(1) Sample design and the collection of property-scale information allow comparisons between monitoring initiatives.

(2) Surveys have included the primary species throughout Western Australia covering both agricultural and pastoral zones.

(3) The duration of sampling to prepare State-wide datasets has been minimised.

(4) Comparable methods to that of other State/ Territories facilitates comparison between States/ Territories.

(5) Information represents a descriptive account of distribution and abundance suitable for detecting, reporting and responding to changes in species distribution and abundance.

Weaknesses

(1) The survey design presents subjective estimates of species distribution and abundance that may require validation.

(2) On-going sampling within the agricultural zone focuses on problem areas, rather than a systematic or random sampling approach that may facilitate the detection of species in new areas.

(3) Field inspections of properties continue, although there are no programs that target the maintenance of descriptive maps reported herein.

(4) The use of a property-based system created some issues of scale regarding the privacy of individual landholders. Information collected was therefore converted to a larger (10 km) grid for map production.

(5) The maps have not been ground-truthed.

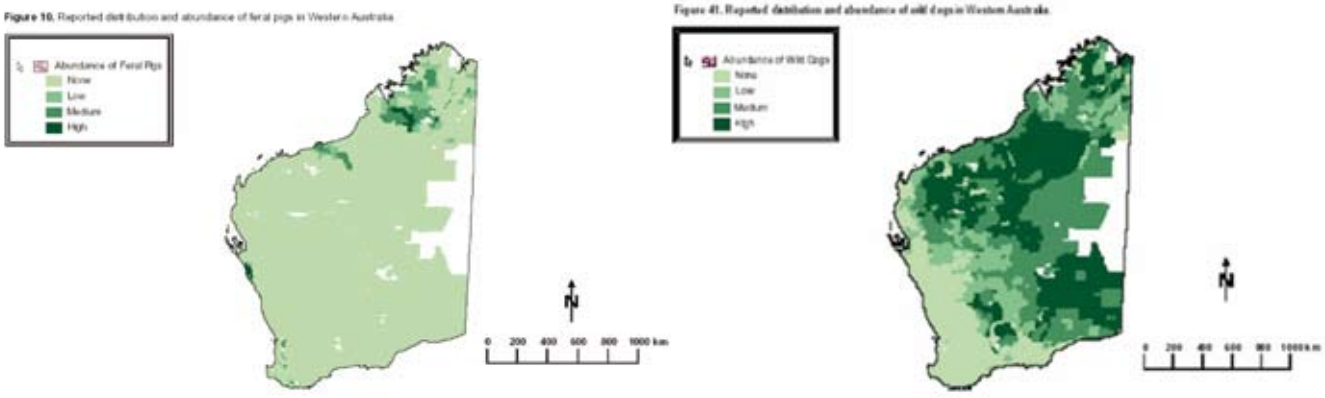
(6) Difficult to use/rely on maps for management decisions given that the data presented is at least 5-7 years old. The lack of ground-truthing means that false negatives would be of particular concern (e.g. in exotic disease emergencies).

Products of information

Maps and documents

Distribution and density maps have been produced for 9 pest species. Maps present 10km² grid blocks representation of the distribution and abundance of species throughout the entire state. The distribution and abundance of feral pigs, and wild dogs are presented in figure 5.

Figure 5: Distribution and density maps for feral pigs and wild dogs for Western Australia (Source: Woolnough *et al*, 2005).



Reporting frequency

On-going monitoring of properties throughout Western Australia continues however there are no current proposals to collate field collected information for maintaining the descriptive maps reported herein.

Assumptions of data

Survey information has been collated between 2002 and 2003. The methods used to report the distribution and abundance of pest animals throughout Western Australia assume:

1) there is a consistency in knowledge and experience between individuals being surveyed and survey staff,
2) information from property inspections is not only accurate and timely, but is sufficiently robust to facilitate comparisons across regions, and
3) variation in species distribution and abundance is sufficiently represented via property-scale and subsequent data aggregation reporting.

Verification of data

While every effort has been taken to minimise perceptual bias, and reduce subjectivity of surveys conducted to prepare distribution and abundance information for Western Australia, verification of survey results would improve the quality of monitoring data reported herein as ground-truthing was not undertaken.

Data management

Data from the state-wide mapping initiative were stored in a MS Access database, with spatial information added and displayed in the Geomedia geographic information system (GIS) package. Data were subsequently incorporated into the CRIS (Client Resource Information System) (Vertebrate Pest Indicator Submission, 2006). Five spatial datasets were used to create the maps and underlying spatial databases which included privately owned properties in the agricultural region, unallocated crown land, DEC reserves, other Government estates and pastoral leases.

DEC have developed a generic native fauna monitoring database for Western Shield data using Microsoft Access which is compatible with GIS. The database entitled *The Fauna File* allows data manipulation and graphic report generation. However, there is no broad scale data contained within this database (Mawson, 2002).

Data custodians

The Department of Agriculture and Food Western Australia (DAFWA) is the custodian of the state-wide data that has been collected and is contained throughout Western Australia.

Information systems

DAFWA manage existing pest animal data within the Client Resource Information System (CRIS) which displays property ownership details. SLIP (Shared Land Information Platform) is a Western Australian initiative to develop a system for accessing data and information products directly from a State repository. It is in development and should minimise duplication of effort, cost-sharing, and deliver infrastructure to support the shared delivery and maintenance of land information by state agencies.

2.7 Northern Territory

Responsibility for management

The Parks and Wildlife Commission of the Northern Territory (part of the Department of Natural Resources, Environment and the Arts, (DNRETA)) is responsible for planning and developing the Territory's system of terrestrial and marine parks and reserves, along with other non-classified land. The Commission undertakes research, implements management programs and develops policies and strategies for the conservation, utilisation and management of flora and fauna throughout the Northern Territory (DNRETA website).

In the Northern Territory, there are a wide range of pest animal species. Some native species, such as flying foxes and saltwater crocodiles are also considered pests under certain situations.

History of pest animal monitoring

Monitoring of large-sized vertebrate pests has been conducted throughout the Northern Territory since the 1970's, mainly using aerial survey (K. Saalfeld, DNRETA, pers. comm. 2006). Monitoring has occurred on a irregular basis, depending on management requirements and operational resources, but has become more frequent since the 1990s. Monitoring is considered a vital pre-cursor to management and a tool for gauging management success. The spatial and temporal scale of surveys has been decided, in part, through consultation with industry and other stakeholder groups. Repeated surveys in the same region have been used to illustrate population trends but seasonal fluctuations in pest abundance have not yet been captured.

Small-sized vertebrate pests have not been monitored as frequently or intensively as large-sized pests, except over the RHD establishment phase (G. Edwards, pers. comm.2006). Monitoring of feral cat, fox, rabbit and wild dog/ dingo numbers has generally been conducted only in conjunction with management strategies and on ground control activities such as baiting (K. Saalfeld, pers. comm. 2006).

Species of importance regarding economic, environmental and social impacts

In the Northern Territory, vertebrate pests are divided into three categories of major, moderate and minor pests. Sixteen mammals, 3 birds, and 1 amphibian have been extracted from the National List of problem animals and evaluated to determine their pest status. Criteria were developed to evaluate the social, economic and environmental impacts of vertebrate pest species. Major, moderate and minor pests were ranked, scored and total scores for each species calculated.

Major pests include:

- feral donkey
- feral horse
- cane toad
- buffalo
- wild pig/ boar
- feral cat
- Red fox

Moderate pests include:

- feral camel
- wild dog/ dingo
- feral goat
- European rabbit

Minor pests include:

- domestic cattle
- turtle dove
- gambusia
- banteng
- brown rat
- house mouse
- house sparrow
- black rat
- pigeon
- sambar deer

Although feral camels are largely confined to the drier parts of the Northern Territory, their populations are estimated to be increasing rapidly and they are an emerging environmental and agricultural pest in the Northern Territory (DNRETA website).

Species targeted for data collection during recent surveys

Large-sized herbivores have been the main target of surveys throughout the Northern Territory. The most recent surveys for each region have included the following species:

- buffalo
- horses
- camels
- donkeys
- cattle

There has been very little monitoring of small-sized pest animals throughout the Northern Territory, although the spread of cane toads has been closely monitored in recent years.

Geographic range and scale of data

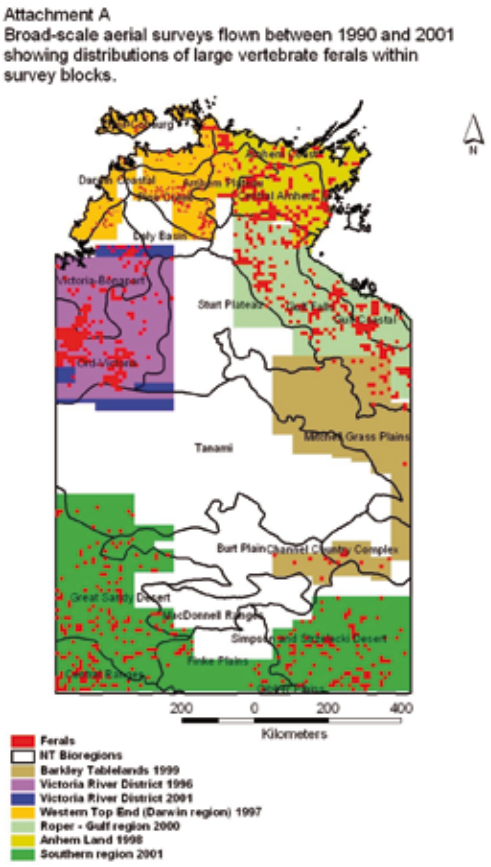
The Northern Territory currently conducts systematic aerial surveys to assess the distribution and abundance of large herbivores at a regional level (Vertebrate Pest Indicator submission, 2006). Broad-scale surveying is undertaken approximately every 1 or 2 years, depending on resources. Surveys target 6 defined regions that are the:

- Barkley Tablelands
- Victoria River District
- Western Top End (Darwin region)
- Roper-Gulf Region
- Arnhem Land
- Southern Region

Some regions such as the Victorian River District have been sampled more regularly due to the availability of resources and perceived pest problems. However, the surveys have not included much of the central regions of the Territory (Figure 6).

Within the Northern Territory much of the information on island biota has been collected *ad hoc*, and is not based on intensive systematic surveys. Although some islands have been intensively surveyed in recent years, many islands remain largely unsurveyed (Rankmore, 2005).

Figure 6: Aerial survey regions of the Northern Territory and sighting locations for large herbivores observed since 1996 (Source: Saalfeld, K).



Method of information collection and reporting

Agencies involved

The Northern Territory conducts systematic aerial surveys to assess the distribution and abundance of large herbivores at a regional level.

Department of Natural Resources, Environment and the Arts (DNRETA)

DNRETA has been responsible for the majority of data collection involving large herbivores in the Northern Territory. Aerial survey methodology has become standardised over the past 2 decades. The survey areas are systematically sampled using 2 observers in a high-wing aircraft travelling on east-west transects at approximately 185km/h and 70 metres above the ground. The transect widths vary between 200 or 250m producing a sampling intensity of between 3.6 and 7.2% within each region (Saalfeld, 1996, 1997, 1998, 2001).

Individual animals are counted and a group size is estimated when large groups of animals are observed. Sightings are recorded with a GPS. Additional information recorded includes species, observer, habitat type, date and time. The numbers of animals counted per transect or grid square is multiplied so as to obtain an average number which can then be transferred into 1 of 5 density categories. The grid squares end up being just over 10x10km and measure out to be an area of approximately 125km² (Saalfeld, 1996, 1997, 1998, 2001). This means that in the NT, the data can be aggregated from an individual animal within a certain time and GPS location, up to a 10km² grid square used for mapping purposes. This increases the accuracy of data and provides robust datasets. Results are described in internal reports or published papers.

The Northern Territory Fauna Atlas is the main source of information on the presence of pest animals on Territory islands.

Period of data collection

The location and timing of aerial surveys varies depending on management requirements and resources. The most recent surveys have included:

- Victoria River District in 1996 from August to September
- Western Top End in 1997 from 7ctober to December
- Arnhem Land in 1998 from November to December
- Barkly Tablelands in 1999 from July to September
- Victoria River District in 2001 from July to August
- Southern NT in 2001 from August to October

Ongoing data collection

Monitoring of large-sized pest animals via aerial surveys throughout regions of the NT is anticipated to be an on-going management initiative. Monitoring of cane toads and areas under invasion is anticipated to continue, and currently involves indigenous communities in some areas (Saalfeld, K, pers. comm., 2006).

Available information

Information to report the distribution of large-sized herbivores is obtainable from DNRETA for regions surveyed since 1996.

Aggregation of existing data

Aerial survey data from each region have been aggregated for ease of interpretation and comparison on a state wide basis. Due to the fine scale of the original data (point samples) collection, aggregation of data is possible. Figure 7 shows an example of aggregation of data from aerial surveys.

Figure 7: Map showing the aggregation of data for a region of the Northern Territory

Strengths and weaknesses of existing methods and data for State-wide reporting

Strengths

(1) Large-herbivore data for the NT has involved rigorous broad-scale field surveying techniques, namely aerial surveys.

(2) Surveys have focussed on several large-sized pest animals in regions of the NT.

(3) Intensive surveying of regions has produced high-quality data for regional management

(4) Data has been collected using consistent methods allowing assessment of management. strategies and changes in populations to be detected.

(5) Reporting has taken place after each sampling attempt.

Weaknesses

(1) There are few initiatives to monitor the distribution and abundance of small and medium-sized pest animals in the NT.

(2) The smaller vertebrate pests such as foxes, cats, dogs and rabbits have been monitored only in conjunction with management strategies and on ground activities such as baiting.

(3) A high proportion of the NT has not been surveyed.

(4) The data that have been gathered for large-sized vertebrate pests have not been extrapolated to prepare descriptive maps of the distribution and abundance of pest animals for the entire Territory, but this could be done based on habitat stratification.

Products of information

Maps and documents

There are regional maps showing vertebrate pest distribution and abundance that have been produced each time sampling has been performed. These maps are included in the technical reports and published papers that describe the results of surveys.

Reporting frequency

Regular aerial surveys of regions have been performed since 1990 throughout the Northern Territory. Sampling is conducted approximately every 1-2 years focussing on 1 region per survey which are subsequently reported. There is no state-wide reporting products providing descriptive information on pest animal distribution and abundance (Saalfeld, K, pers. comm., 2006).

Assumptions of data

The data available for pest animals described herein for the Northern Territory has been collected over a long period of time. To examine trends over time, it would be assumed that:

- regions are surveyed equally regarding intensity and exhibit the same probability of detection of species;
- consistency in climatic conditions and resource suitability of regions if regional data are compared simultaneously as surveys were conducted across a 5 year period; and
- the aerial survey methods are suitable for all species in the survey.

Verification of data

Pest animal data for the Northern Territory have been obtained using robust and repeatable field sampling procedures. However, regions have not been surveyed simultaneously and repeated. The existing data cannot be used to generate a state-wide distribution of pest animals. Existing data can be used to assess long term regional trends.

Data management

Information obtained on pest animals in the Northern Territory is maintained in small databases (Saalfeld, K, pers. comm., 2006). Data is maintained as hard copy products and stored electronically.

Data custodians

The Department of Natural Resources Environment and the Arts, and the Parks and Wildlife Commission of the Northern Territory are custodians of survey data on pest animals.

Information systems

There are no well established information systems for pest animal data in the Northern Territory. The data is stored in both databases as hard copy products.

2.8 Tasmania

Responsibility for management

There are 3 Agencies responsible for the management of pest animals throughout Tasmania; the Department of Primary Industries, and Water (DPIW); the Parks and Wildlife Services of Tasmania (PWS); and Forestry Tasmania.

The Fox Free Task Force is a multi-agency initiative to eradicate foxes from Tasmania.

History of pest animal monitoring

There have been no broad-scale initiatives to monitor the state- wide distribution and abundance of pest species throughout Tasmania. Monitoring of pest animals throughout the State has largely been focused on specialised monitoring programs for a select number of species in selected areas, such as rabbits. Monitoring often forms the basis for determining the level, location and effectiveness of control programs.

Distribution data on pest animals is maintained on a web-based Natural Values Atlas. There have been no targeted programs to collect pest animal data except a one-off survey by PWS Rangers in the Tasmanian Wilderness World Heritage Area in 2000.

There has been incidental pest animal monitoring undertaken as part of a program run by DPIW to actively monitor harvested wildlife (Bennetts wallaby and Brushtail possum) numbers since 1975 (M. Driessen, Department of Primary Industries, and Water (DPIW), pers. comm., 2006).

DPIW has monitored an isolated rabbit population at Strathgordon within southwest Tasmania as part of a control and eradication program. Impacts on vegetation were also monitored.

Forestry Tasmania have been undertaking monitoring of damage levels associated with various grazing and browsing animals (native and introduced) in plantation areas for many years. These records have been used for determining when and how control programs should be undertaken (Wardlaw, 2004).

Monitoring for feral pigs on Flinders Island has also been used for prescribed control programs.

The management of pest animals throughout the state and the development of programs involving monitoring have recently included (Resource Planning and Development Commission, State of the Environment Reporting in Tasmania, 2003):

- The State Government formed 'The Fox Free Tasmania Taskforce' to prevent the establishment of foxes in Tasmania;
- The Carp eradication program has been ongoing at Lake Crescent and Lake Sorell;
- A study of the impact of feral pigs on Flinders Island (Underwood, 2000) has been undertaken, and eradication measures commenced in cooperation with the local community;
- An Australian Government-funded goat eradication/ control program has been carried out in key areas of the State during the past 5 years and has achieved localised success;
- Aerial and ground based monitoring program for deer in the Central Plateau Conservation Area, part of the Tasmanian Wilderness World Heritage Area; and
- An introduced animal management strategy for the Tasmanian Wilderness World Heritage Area – currently in draft form and due for completion in 2006/07.

Species of importance regarding economic, environmental and social impacts

Pest animals of significance in Tasmania include trout, redfin perch, starlings, rabbits, feral goats, feral cats, feral pigs, ferrets and foxes. Trout have been identified as a major threat for several native fish species influencing their distribution through predation and competition. Starlings compete with the endangered Orange-Bellied Parrot for nest locations although are not linked with the decline of any native species on mainland Tasmania. Feral cats are widespread and can have an impact on community structure and local populations. They have had a significant impact on some islands such as Macquarie Island and islands containing mutton bird rookeries. Feral pigs are found in parts of the State, including some islands. Foxes have only recently become a species of importance by a number of illegal introductions. Some native animals are also considered pests such as wallabies, possums, cockatoos, introduced corellas, kookaburras and black swans as they cause localised damage to agricultural crops, forestry plantations, and pastures. The lyrebird, introduced to Tasmania in the 1930s and 40s, is currently known to be spreading throughout wet forests but the potential impacts have not been measured.

Two species are currently the targets of major eradication programs in Tasmania: European Carp; and Foxes. A large community-based monitoring program has been formed to encourage reporting of fox sign (DPIW website).

Species targeted for data collection during recent surveys

DPIW undertake property inspections, and provide advice on the control of pest animals, and are involved in monitoring of various native species (Brush-tailed possums, Bennett's wallabies and Tasmanian pademelons), as well as introduced species, such as the rabbit. DPIW are also involved in monitoring for the presence of foxes. A monitoring program has been established by DPIW to determine whether deer are spreading into parts of the Tasmanian Wilderness World Heritage Area (M. Driessen, pers. comm., 2006).

Forestry Tasmania conducts annual surveillance of plantation estates to detect damage caused by pests (insects and mammals) and disease. Damage caused by rabbits and native wildlife are recorded (Wardlaw, 2004).

Many Agencies are involved in the 'Fox Free Task Force' to locate and eradicate foxes from Tasmania (Vertebrate Pest Indicator submission, 2006).

Geographic range and scale of data

There have not been any initiatives to report the state-wide distribution and abundance of pest animals throughout Tasmania, nor are there any dedicated programs for monitoring pest animal species throughout their entire range. Most data available for pest animals has been collected for specialised monitoring purposes across relatively small areas. Monitoring in some areas involves transect surveys to determine season or resource driven changes in animal abundance.

DPIW have been undertaking spotlight surveying for wallabies and possums since 1975, providing information on the distribution and abundance of many introduced pest species, including deer, cats, hares and rabbits (G. Hocking, pers. comm., 2006). These data constitute the best long-term monitoring information for introduced pest animals in Tasmania.

Method of information collection and reporting

Agencies involved

DPIW

The Resource Management and Conservation Division of DPIW has undertaken spotlight surveys (to provide an estimate of population density around the transect lines) since 1975 as part of an annual census of wallabies and possums. While the surveys primarily target wallabies and possums along 132 transects (each 10km

in length) positioned throughout the state, sightings of non-target vertebrate pests are simultaneously recorded. These species include deer, cats, hares and rabbits, and all data are recorded with a spotlight survey database (RPDC State of the Environment, 2003). DPIW also have established an on-going monitoring and control program on Flinders Island for rabbits and pigs. In the Central Plateau Conservation Area, aerial transects, spotlight and faecal count surveys have been established (M. Driessen, pers. comm., 2006).

Forestry Tasmania

Forestry Tasmania undertakes monitoring of damage levels associated with various grazing and browsing animals (native and introduced) in plantation areas for damage mitigation purposes. Direct estimates of browsing animal abundance are not obtained (Wardlaw, 2004).

Period of data collection

DPIW have been monitoring pest animals annually throughout the State along 132 set transects since 1975 (G. Hocking, DPIW, pers. comm., 2006).

Deer monitoring in the Central Plateau Conservation Area commenced in 2004 (M. Driessen, pers. comm., 2006).

Ongoing data collection

Indirect monitoring of pest animals (deer, rabbits, hares and cats) is expected to continue through the monitoring of possums and wallabies by DPIW.

The Draft Regional NRM Development Strategy for Tasmania indicates that on-ground monitoring and the integration of pest and disease management strategies are essential, and effective and long term monitoring of pest animal populations are required.

Available information

There are currently no datasets that describe state-wide distribution or abundances of pest species in Tasmania. Some information on distribution of pests is currently available on the web via the Natural Values Atlas). The State of the Environment Tasmania Report describes the distribution of many pest species throughout Tasmania, which has been taken form the Natural Values Atlas, formerly GTSpot.

Information gained through the DPIW transect surveys for browsing wildlife, provide information on the distribution and abundance of many introduced pest species, namely deer, cats, hares and rabbits. These data constitute the most valuable long-term monitoring information for introduced pest animals in Tasmania.

Aggregation of existing data

Data collected as part of surveys throughout Tasmania have been aggregated for mapping and are available via the Natural Values Atlas, however there is no specific strategy to collect records on a regular basis although new information can be placed on at any time.

Strengths and weaknesses of existing methods and data for State-wide reporting

Strengths

(1) Monitoring initiatives throughout Tasmania have provided long-term and detailed information on the distribution and abundance of a number of pest animals.

Weaknesses

(1) Monitoring has focussed on selected areas and selected species; and

(2) Information on the distribution and abundance of pest animals has primarily been obtained indirectly through monitoring of native browsing wildlife although distribution data has been collected from a wide range of sources, staff, public, researchers observations, and specific pest programs.

Products of information

Maps and documents

State-wide pest animal presence information for Tasmania are available via the web – Natural Values Atlas formerly known as GTSpot. The State of Environment (SOE) Report for Tasmania (2002) describes the distribution of pest animals throughout the State which has been derived from the Natural Values Atlas database.

Reporting frequency

There has been no annual reporting of the state-wide distribution of pest animals throughout Tasmania. However, indirect monitoring through the annual DPIW transect surveys provides information for selected areas of the State.

Assumptions of data

The monitoring information for pest animals has largely been obtained from browsing wildlife surveys using transects and spotlight counts. It is assumed that these surveys are sufficiently capable of detecting pest animals (deer, cats, hares and rabbits) throughout their range.

Verification of data

It is unclear whether descriptive information reported as part of the State of Environment Report for Tasmania have been verified using field sampling procedures. It is also not known whether verification of information on the distribution and abundance of pest animals (deer, cats, hares and rabbits) from DPIW transects has occurred.

Data management

Information on the distribution and abundance of pest animals from transects surveyed by DPIW are maintained in a centralised database. These data represent the majority of distribution and abundance information for pest animals in Tasmania. Point data on the distribution of a range of pest species is available on the Natural Values Atlas. The information system of most relevance to Tasmania is the Natural Values Atlas of Tasmania (formerly GTSpot). The Atlas contains plant and animal records as point locations from incidental observations of wildlife, as well as some information from pest animal specific surveys (M. Driessen, pers. comm., 2006).

Data custodians

DPIW store, maintain and manage datasets from surveys and transect monitoring throughout the State. Other information may be available from Parks and Wildlife Service, and Forestry Tasmania.

Information systems

There are no dedicated information systems for collating pest animal information from all agencies with in Tasmania.

3. Summary of State and Territory Information

3.1 Methods of data collection

The invasive animal species that have been assessed in broad scale surveys throughout Australia include the European rabbit, Red fox, wild deer, feral pig, feral goat, wild dog and dingo, wild horse, feral cat, feral buffalo, feral camel, feral donkey, and feral cattle and sheep (table 1). There are many other introduced species that impact on the environment, agricultural production and society, however many have not been previously considered as a species of importance and subsequently have not been included in this summary.

Although not all species in this review inhabit all states and territories of Australia, many in fact occupy localised distributions, all species reported on in this report impact on the environment, economy and/or society. Some species are also considered 'emerging species' and are spreading into new regions and impacting on the environment and agricultural production in the process, such as the cane toad. Many of these species require strategies to prevent them from becoming widespread and well-established.

All States and Territories undertake monitoring of invasive animals. There are many similarities in the approaches used to measure and monitor invasive animal populations throughout the States and Territories of Australia, including the species targeted for monitoring, the methods implemented (such as questionnaires), and survey design. There are also several differences in previous and current monitoring initiatives between the States and Territories; these are differences in reporting scale, survey robustness and relative frequency of surveys. While several initiatives focusing on invasive animal distribution and abundance have utilised comparable methods and techniques, namely those of NSW and WA, most States and Territories have implemented methods that are incomparable. As a result, difficulties may emerge in drawing comparisons across State and Territory jurisdictions, and these issues need to be taken into consideration in generating national products of invasive animals.

While the approaches used to monitor invasive animals differ considerably (table 2), the most widely used methods provide broad-scale information on invasive animals obtained from face-to-face surveys, which have been used in 4 States. Table 2 outlines the methods used by the States and Territories. Several State/ Territories have implemented intensive monitoring at a regional level to determine management priorities and support decision-making (table 3). Information available in these states have been obtained from robust field sampling procedures providing valuable information for local and regional management. Field sampling procedures have included aerial surveys for large herbivores, spotlight counts of introduced predators and rabbits, and sand-pad monitoring for introduced predators. In addition, independent wildlife monitoring programs have provided data to determine the distribution and abundance of some invasive animals. Techniques associated with control activities and impact monitoring programs have also provided information on invasive animals.

The species targeted for monitoring throughout Australia vary as a result of differences in species abundance, land tenure, primary production, operational resources, and impacts. Some species have been surveyed in all States/Territories, while others have been surveyed in only a small proportion of their range. The products generated from state- based surveys vary substantially as a result of difference in the methods used to survey species, and differences in spatial and temporal scales between surveys. Other differences relate to the history of monitoring. In some states, monitoring of species has been undertaken for many years, while in others, particularly those where species are emerging problems, monitoring has been a recent development.

While the species monitored throughout the States/Territories are relatively similar, the intensity of monitoring varies substantially between the States/ Territories. For instance, broad-scale knowledge- based surveys to report the distribution and abundance of rabbits in New South Wales contrasts with intensive monitoring of rabbits in Victoria at localised areas. As a result, these differences make comparisons between States difficult.

There are a variety of information management systems used to capture, store, manage and report information on the distribution and abundance on invasive animals throughout Australia. They range from localised desktop databases to web-enabled information systems for on-going pest management activities and reporting.

Table 1. Summary of methods, products and systems used to monitor pest animals in each state and territory of Australia.

State/ Territory	NSW	ACT	QLD	NT	WA	SA	VIC	TAS
Chief governing agency	NSW DPI NSW DEC	Environment ACT	DNRM&W	NRETA, Parks and Wildlife NT	DAFWA, CALM	DEH, DWLBC, APCG	DSE, Parks Victoria	DPIW, PWS
Species monitored	Rabbit Wild Deer Pig Wild Dog/ Dingo Goat Fox	Rabbit Wild Deer Pig Wild Dog/Dingo Goat Fox Horse E.G Kangaroo	Rabbit Wild Deer Pig Wild Dog/ Dingo Goat Fox Cat	Buffalo Horse Camel Donkey Red Kangaroo Cattle	Donkeys Pigs Camels Deer Horses Goats Livestock Wild Dog/Dingo	Rabbit Wild Deer Pig Goat Fox Cat	Rabbit Pigs Wild Dog/ Dingo Goat Fox	Rabbit Pig Fox Harvested Wildlife
Survey Method	Face to Face Questionnaires (2002, 2004)	Face to Face Questionnaires (NSW), Damage plots, sand pads, aerial surveys (Pigs)	Annual Pest Distribution Survey (APDS)	Systematic aerial Surveys	Face to Face Questionnaires, aerial surveys	Questionnaires, Aerial surveys (goat, kangaroo), Transects (fox,cat,rabbit)	Transects, sand pads, spotlight surveys, baiting, passive tracking	Transect counts, spotlight surveys, aerial surveys, faecal counts
Data Scale	5x5 km² grid	5x5 km² grid	50x50 km² and 17x17 km² grid	Transect coverage (varied)	10x10 km² grid	50x50 km² grid	Localised, Regional	Regional
Data Range	State-wide ACT inclusive	State-wide	State-wide	Regional	State-wide	State-wide	Regional	Regional
Mapping data available?	Yes	Yes (from NSW)	Yes	Yes	Yes	Yes	No	Limited
Information System	None Developed	None Developed	PestInfo	None Developed	CRIS SLIP	Pest2000 PIMS	IPMS	Natural Values Database Atlas

Table 2: Methods used by each State/ Territory and the species chosen for each method.

Method	VIC	NSW	SA	ACT	QLD	WA	NT	TAS
Face to Face Surveys* Mail out survey		Fox Rabbit Pig Deer, Goat Wild dog/ dingo	Fox Cat Pig Rabbit Goat Deer	Fox Rabbit Pig Goat Deer Wild dog/ dingo	Cat Fox Goat Pig Deer Rabbit Wild dog/ dingo	Camel Sheep Donkey Horse Pig* Cattle Goat Fox Deer Rabbit Wild dog/ dingo		
Spotlight Transects	Rabbit Fox		Rabbit Fox Cat	Rabbit Cat Fox Red-Neck Wallaby				Deer Cat Rabbit Hare
Aerial surveys			Goat			Pig Horse Goat Donkey Camel	Buffalo Horse Donkey Camel Red kangaroo	Deer Pig
Damage Plots				Pig				
Sand Pads	Fox							
Scat/ Sign Analysis	Fox							Deer Pig

Table 3. Existing data for the ten most significant pests, within each state or territory in Australia.

S- State-wide Data, R- Regional Data, C- Control based monitoring

Species	NSW	QLD	VIC	ACT	SA	WA	NT	TAS
Feral pig	**S**	**S**	✗	**S, R**	**S**	**S**	**R**	**R**
Feral goat	**S**	**S**	**R**	**S, R**	**S, R**	**S**	**R**	**R**
Fox	**S**	**S**	**R**	**S, R**	**S**	✗	**C**	**R**
Rabbit	**S**	**S**	**R**	**S, R**	**S**	✗	**C**	**R**
Wild Dog/ Dingo	**S**	**S**	**C**	**S, R, C**	✗	**S**	**C**	✗
Feral cat	✗	**S**	✗	**R**	**S**	✗	**C**	**R**
Cane toad	**R**	**R**	**N/A**	**N/A**	**N/A**	**N/A**	**R**	**N/A**

Species	NSW	QLD	VIC	ACT	SA	WA	NT	TAS
Wild deer	**S**	**S**	✗	**S, R**	**S**	**S**	✗	**R**
European carp	✗	✗	✗	✗	✗	✗	✗	**R**
Common Starling	✗	✗	✗	✗	✗	**R**	✗	✗
Wild horse	**R**	✗	**R**	**R**	✗	**R**	**R**	✗
House mouse	✗	✗	✗	✗	✗	✗	✗	✗
Feral camel	✗	✗	✗	✗	✗	**R**	**R**	**N/A**
Feral buffalo	**N/A**	**R**	✗	**N/A**	✗	✗	**R**	**N/A**
Feral donkey	✗	✗	✗	✗	✗	✗	**R**	✗
Feral cattle	✗	✗	✗	✗	✗	✗	**R**	✗
Feral sheep	✗	✗	✗	✗	✗	✗	**R**	✗
Brown hare	✗	✗	✗	✗	✗	✗	✗	✗
Red-eared slider turtle	✗	**R**	**N/A**	**R**	**N/A**	**N/A**	**N/A**	**N/A**
Ferrets/Polecat	✗	✗	✗	✗	✗	✗	✗	✗
Indian Palm Squirrels	✗	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Gambusia	✗	✗	✗	✗	✗	✗	✗	✗
Indian Myna	✗	✗	✗	✗	✗	✗	✗	✗

4. Concluding remarks

This report provides information on the methods used throughout Australia to gain information on the distribution and abundance of invasive animals. It has been prepared to identify what approaches have been used to monitor invasive animal populations, and to establish whether consistency in data collection can be reached to facilitate reporting across jurisdictions at regional, state and national levels. The report presents information collated and summarised following consultation with state representatives, and examination of various available material. The issues addressed herein include monitoring methods, data availability and information management, to address long term objectives of the NLWRA and the IA CRC. The summary presents information regarding recent and past monitoring initiatives, regional and broad-scale activities, and on-going monitoring programs in each State and Territory.

This report provides a summary of the methods used to assess and report broad scale information on the abundance distribution and abundance of invasive animals throughout Australia and the data currently available to address current and ongoing reporting needs.

This report summarises the previous and current initiatives for measuring invasive animal populations at the regional and state-level throughout Australia. It is recommended that the following be implemented for national and state /territory invasive animal monitoring:

- Data collection and reporting standards are developed for collection of invasive animal information for on-going monitoring, evaluation and reporting at regional, state and national scales;
- A national framework and information system for reporting state-based information is required to support national programs and funding initiatives; and
- National agreement is reached regarding strategies for the collation of existing data for national reporting activities.
- Consistency is reached regarding data collection to allow national reporting of meaningful information.

Acknowledgements

This report is part of a project funded by the Invasive Animals Cooperative Research Centre (IACRC) and the National Land & Water Resources Audit (NLWRA) as part of a collaborative 2005-2007 work program. We are grateful to all those who supplied information and example products for this report, and those who shared information on current activities regarding monitoring of invasive animals in Australia. In particular, we would like to thank staff from the following organisations:

Victorian Government: Department of Sustainability and Environment (DSE), Department of Primary Industries (DPI) and Vertebrate Pest Research Unit (VPRU), Catchment and Agriculture Services (CAS), Arthur Rylah Institute (ARI), and Parks Victoria;

New South Wales Government: DPI Vertebrate Pest Research Unit (VPRU), and Department of Environment and Conservation (DEC);

South Australia Government: Animal and Plant Control Group (APCG), and Department of Water, Land, and Biodiversity Conservation (DWLBC);

Australian Capital Territory Government: Environment ACT;

Queensland Government: Department of Natural Resources, Mines and Water (DNRMW);

Western Australia Government: Department of Agriculture and Food Western Australia (DAFWA), and Department of Environment and Conservation (DEC);

Northern Territory Government: Natural Resources, Environment and the Arts (NRETA);

Tasmania Government: Department of Primary Industries, and Water (DPIW); and

Australian Government: Department of Environment and Heritage (DEH), and Department of Agriculture, Fisheries and Forestry (DAFF).

We are also grateful to representatives who attended the National Weeds and Invasive Animals Information workshop in Hobart in March 2006. All contributions were greatly appreciated.

References

ACT Commissioner for the Environment (2003). *State of the Environment Report, Australian Capital Territory (2003).* ACT Government. Indicator- PestAnimals

http://www.envcomm.act.gov.au/__data/assets/pdf_file/12145/pestanimals03p.pdf

Backholer, J. (2005). *An overview of IPMS*. Catchment and Agriculture Services (CAS) Landscape Protection Strategies, Victoria.

Bomford, M. (2003). *Risk Assessment for the Import and Keeping of Exotic Vertebrates in Australia*, Bureau of Rural Sciences, Canberra.

Cross, J. (2005). *Vertebrate Pest Manual- a guide to pest animal management in Queensland.* The State of Queensland (Department of Natural Resources and Mines).

Department of Agriculture, Forestry and Fisheries (DAFF), and Department of Environment and Heritage (DEH), *Impacts of regionally significant invasive vertebrate pests, excluding fish: (indicator status: for advice), 2006.*

http://www.nrm.gov.au/monitoring/indicators/vertebrate.html

Department of Conservation and Land Management (CALM), Government of Western Australia- Nature Base website:

http://www.naturebase.net/about_calm.html

Department for Environment and Heritage (DEH) website (2006).

http://www.environment.sa.gov.au/reporting/index.html

Department of Natural Resources and Environment (2002). *Victorian Pest Management - A Framework for Action (2002).* State Government Victoria.

http://www.dpi.vic.gov.au/DSE/nrenpa.nsf/646e9b4bba1afb2bca256c420053b5ce/0224055b2c56451cca25713e0015f176/$FILE/VPMFMain.pdf

Department of Natural Resources and Mines (2005). *Pest Strategies Information Sheet*. Land Protection, Queensland Government.

http://www.nrm.qld.gov.au/factsheets/pdf/pest/pp60.pdf

Department of Natural Resources and Mines (2002-2006). *Queensland pest animal Strategy.* Land Protection, Queensland Government.

http://www.nrm.qld.gov.au/pests/management_plans/pdf/qld_animal_strategy.pdf

Department of Primary Industries, Water and Environment (DPIWE) website- weeds, pests and disease.

http://www.dpiwe.tas.gov.au/inter.nsf/ThemeNodes/DREN-4VH82R?open

Department of Sustainability and Environment (DSE) Victoria Website (2005) - Pest Animals

http://www.dpi.vic.gov.au/dpi/nrenfa.nsf/FID/-8F866E4D49D4CD9CA256C85001A36D7?7penDocument

Department of Water, Land and Biodiversity Conservation (2004). *Natural Resources Management Act 2004- The Facts. Fact Sheet 10.* South Australian Government.
http://www.dwr.sa.gov.au/files/fs10.pdf

Department of Water, Land and Biodiversity Conservation (DWLBC) website- Biodiversity/ Pest animals and weeds (2006):
http://www.dwlbc.sa.gov.au/biodiversity/pests/distribution.html#Distribution_Maps_of_Exotic_Animals_in_Sth_Aust

Environment ACT (2002). *ACT Vertebrate Pest management Strategy*. Conservation Series No. 19. Publishing Services for Environment ACT, Canberra.

Government of South Australia (2003). *State of the environment report for South Australia, 2003.* South Australia Central, Environmental Protection Agency and South Australian Government.
http://www.environment.sa.gov.au/soe2003/report.html

Hone, J. (2002). *Feral Pigs in Namadgi National Park, Australia: dynamics, impacts and management*. Biological Conservation 105 pp 231-242.

Long, J.L. (1988). Introduced Birds and Mammals in Western Australia. Technical Series 1. Agriculture Protection Board of Western Australia.

Marscak, P. (1989). WEDPP: A report on feral pig research programs in Western Australia, 1987-1989.)

Mawson, P. (2002). *Operational Fauna Databases within the Conservation and Land Management- A brief summary.* Journal of the Royal Society of Western Australia, 85: 139-141.
http://www.ecu.edu.au/pa/rswa/workshop/pmawson.htm

Mcleod, R (2004) *Counting the Cost: Impact of Invasive Animals in Australia 2004*. Cooperative research Centre for Pest Animal Control. Canberra.

Natural Resources, Environment and the Arts (NRETA) website. Northern Territory Government.
http://www.nt.gov.au/nreta/wildlife/animals/index.html

New South Wales National Parks and Wildlife Service website:
http://www3.environment.nsw.gov.au/npws.nsf/Content/Pest+animals

Parks Victoria (2004). *Threat Monitoring Protocols- European Rabbit, European* Fox, Deer, and Cat.

Queensland Government Website- Pest animals:
http://www.nrm.qld.gov.au/pests/pest_animals/declared/index.html

Rankmore, B. (2005). *Introduced Animals on Northern Territory islands: improving Australia's ability to protect its island habitats from feral animals*. Biodiversity Conservation Unit, Department of Natural Resources, Environment and the Arts, Northern Territory, Australia.

Resource Planning and Development Commission (2003). *State of the environment Reporting in Tasmania (2003).* Various chapters:

- Biodiversity – Threatening Processes- Weeds, pests and Disease- Animal Pests
  http://www.rpdc.tas.gov.au/soer/bio/4/issue/23/ataglance.php
- Examples of Environmental pests and their distribution in Tasmania, 2002.
  http://www.rpdc.tas.gov.au/soer/table/83/index.php

Saalfeld, W.K. (1996). *Aerial survey of donkey and horse populations in the Victoria River district.* Wildlife Management Unit, Wildlife Division, Parks and Wildlife Commission of the Northern Territory, Australia.

Saalfeld, W.K. (1997). *Aerial survey of buffalo, horses, and red- tail black cockatoo in the western top end.* Conservation Management Unit, Wildlife Division, Parks and Wildlife Commission of the Northern Territory, Australia.

Saalfeld, W.K. (2001). *Aerial survey of donkey and horse populations in the Victoria River District.* Parks and Wildlife Commission of the Northern Territory, Australia.

Saalfeld, W.K. (1998). *Aerial survey of large vertebrates in Arnhem Land.* Conservation Management Unit, Wildlife Division, Parks and Wildlife Commission of the Northern Territory, Australia.

Scott, A. (2003). *DPIWE NRM Issues Paper.* Department of Primary Industries, Water and the Environment (DPIWE), Tasmania.

Southwell, C.J. and Pickles, G.S. (1993). *Abundance, Distribution and rate of increase of feral goats in Western Australia.* Rangel. J 15(2) pp 334-8.

Spatial Vision (2005). Wildlife Atlas Press Release (March 22, 2005) *Redevelopment of Victoria's Wildlife Atlas.* Department of Sustainability and Environment (DSE) Victoria.
http://www.spatialvision.com.au/html/r_wildlifeatlas.htm

Spencer, P.B.S and Woolnough, A.P. (2004). *Size should matter: Distribution and genetic considerations for pest animal management.* Ecological Management and Restoration **5**: 231-233.

Supplementary State of the Environment report for South Australia (2003).
http://www.environment.sa.gov.au/soe2003/sup_report/biodiversity/introduced.pd

The Animal and Plant Control Group (APCG) website information (2006).
Department of Water, Land and Biodiversity Conservation, South Australian Government.
http://www.dwlbc.sa.gov.au/biodiversity/pests/apcc.html

Underwood, S. (2000). *The Impact of Feral Pigs (Sus scrofa) on Flinders Island, Tasmania,* Baseline 2000, unpublished report.

Wardlaw, T. (2004). *Inquiry into the impact on agriculture of pest animals- Submission by Forestry Tasmania.* Biology & Conservation Branch, DPIWE, Tasmania.

West, P. & Saunders, G. (2003). *Pest Animal Survey- an analysis of pest animal distribution and abundance across NSW and the ACT.* NSW Agriculture.

Woolnough, A., Gray, G.S., Lowe, T.J., Kirkpatrick, W.E., Rose, K., and Martin, G.R. (2005). *Distribution and abundance of pest animals in Western Australia: A survey of Institutional Knowledge.* Vertebrate Pest Research Section, Department of Agriculture, Western Australia (DAWA).

Wilson, G., Dexter, N., O'Brien, P., and Bomford, M. (1992). *Pest Animals in Australia, A survey of introduced Wild Animals*. Bureau of Rural Resources, Kangaroo Press Ltd, Kenthurst.

Appendix

Appendix 1: State and Territory Government Agencies engaged in the review

Victoria

Department of Sustainability and Environment

Department of Primary Industries, Vertebrate Pest Research Unit

Arthur Rylah Institute

Catchment and Agriculture Services

Parks Victoria

New South Wales

Department of Primary Industries, Vertebrate Pest Research Unit

Department of Environment and Conservation

South Australia

Department of Water, Land, Biodiversity and Conservation

Animal and Plant Control Group

Department of Environment and Heritage

Australian Capital Territory

Environment ACT

Queensland

Department of Natural Resources, Mines and Water

Western Australia

Department of Agriculture and Food Western Australia

Department of Environment and Conservation

Northern Territory

Department of Natural Resources, Environment and the Arts

Tasmania

Department of Primary Industries and Water

Australian Government

Department of Environment and Heritage

Bureau of Rural Sciences