Australian Government

National Land & Water Resources Audit

An initiative of the Australian Government

Significant invasive species (vertebrate pests)

Status of information for reporting against indicators under the National Natural Resource Management Monitoring and Evaluation Framework

Invasive Animals Cooperative Research Centre

www.nlwra.gov.au

About the National Land & Water Resources Audit

The National Land & Water Resources Audit ('the Audit') provides data, information and nationwide assessments of Australia's land, water and biological resources to support sustainable development. The Audit commenced in 1997 and published the first set of detailed assessment reports in 2002.

The Audit (2003–08) has six key areas of activity:

- developing a consistent national reporting mechanism for collating natural resource information collected under the National Natural Resource Management Monitoring and Evaluation Framework

- collating information to support the national State of the Environment (SoE) reports

- developing nationally consistent, but regionally relevant integrated resource condition reports

- facilitating reporting on the ongoing collection of natural resource information for key theme areas, including those related to the National Natural Resource Management Monitoring and Evaluation Framework

- reporting on national data and information management (in collaboration with ANZLIC — the Spatial Information Council)

- developing national assessments (as requested) and supporting program evaluations.

For further information see http://www.nlwra.gov.au

The Audit's mission

To provide data, information and nationwide assessments of Australia's land, water and biological resources to support sustainable development.

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Disclaimer

We invite all interested people, both within and outside the government, to make use of the Audit's reports, information, its Atlas and products. We encourage you to discuss the Audit's findings with the various partners and contributors that have prepared this information.

The Commonwealth accepts no responsibility for the accuracy or the completeness of any material contained in this report and recommends that users exercise their own skill and care with respect to its use.

Foreword

Effective management of natural resources requires good quality data and information at the right level of detail to be available for those who need it. Australia invests significant resources each year in the collection and maintenance of data to inform natural resource management decisions.

Since 1997, the National Land & Water Resources Audit ('the Audit') has played a vital role in the national coordination, collation and reporting of this information. The Audit collaborates with a range of partners, including the Australian Government, state and territory governments, regional natural resource management bodies, industry, the private sector and community organisations.

This booklet is part of a series that describes the status of data and information relevant to national indicators agreed under the National Natural Resource Management Monitoring and Evaluation Framework. It is a result of collaboration between the Audit, the Invasive Animals Cooperative Research Centre, and all states and territories. It specifically reports on the status of information relating to the two indicators 'distribution and abundance of significant invasive vertebrate pests' and 'impacts of significant invasive vertebrate pests'. Clarifying the status of data and information on significant invasive vertebrate pests is a vital step towards more strategic future investment.

Noteworthy advances with invasive vertebrate pest information include:

- combined sponsorship by the Department of Agriculture, Fisheries and Forestry and the Department of the Environment, Water, Heritage and the Arts

- a strong partnership between the Australian Government and state and territory governments through the Australian Vertebrate Pests Committee

- significant progress with invasive vertebrate pest extent and impact indicators and reporting, building on the achievements of previous initiatives

- continuing work on filling key data gaps, particularly distribution and abundance information

- recommendations for further impact monitoring and research, and the inclusion of new and emerging pest species within the National Natural Resource Management Monitoring and Evaluation Framework

- improved linkages between the invasive vertebrate pests theme and other themes, such as land use.

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Acronyms and abbreviations

AAC	Audit Advisory Council
ARO	Australia's Resources Online
BioSIRT	Biosecurity, Surveillance, Incident Response and Tracing
CRC	Cooperative Research Centre
IBRA	Interim Biogeographic Regionalisation for Australia
National M&E Framework	National Natural Resource Management Monitoring and Evaluation Framework
NFACP	National Feral Animal Control Program
NLWRA	National Land & Water Resources Audit ('the Audit')
NRM	natural resource management
VPC	Australian Vertebrate Pests Committee

Contents

Executive summary

Nationally consistent information on the extent, abundance and impacts of invasive animals is critical for managing Australia's natural resources and for addressing the problems caused by invasive animals to agriculture, the environment and society. In Australia, invasive animals cause more than one billion dollars damage each year (McLeod 2004, Tracey et al 2007), and the impacts of many species are only just emerging.

The National Land & Water Resources Audit ('the Audit'), the Invasive Animals Cooperative Research Centre and all states and territories have produced the first national assessment of significant invasive animals in Australia to use a consistent methodology. This assessment provides a means for reporting against the indicators for *Ecologically Significant Invasive Species* (*Vertebrate Pests*) under the National Natural Resource Management Monitoring and Evaluation Framework (the National M&E Framework).

Two indicators for monitoring and reporting on invasive vertebrate pests were recommended by the National Coordinating Committee — the Australian Vertebrate Pests Committee (VPC). The first indicator, 'distribution and abundance of significant invasive vertebrate pests', has been endorsed by the VPC and the Audit Advisory Council (AAC). The second indicator, 'impacts of significant invasive vertebrate pests', has been endorsed by the VPC and the AAC, and a methodology to report against the indicator is being trialled. This booklet summarises the information available to report on these indicators.

A national assessment during 2006–07 used a consistent approach and agreed data standards to report on these indicators. *Assessing Invasive Animals in Australia 2008* (NLWRA and IA CRC 2008) provides the outcomes of the assessment of the extent, abundance and impacts of 10 of Australia's nationally significant invasive animals and uses the first seamless national invasive animals dataset that has been compiled using agreed data standards. It identifies the extent of pest problems and the areas where pest problems are most severe throughout Australia.

Importantly, the assessment:

■ showcases the National M&E Framework as a mechanism for monitoring and reporting invasive animals in Australia

- presents information for management agencies at regional, state and national levels as a baseline for ongoing monitoring and reporting activities

- provides management authorities with information to support the development of policy, management and biosecurity strategies; evaluate management decisions; and target pests and their impacts in Australia.

Information products are available, including extent and abundance maps at regional levels (eg natural resource management [NRM] regions) and state and national levels. Information on impacts has been summarised through a series of case studies from relevant authorities providing a snapshot of information from existing monitoring and management programs. Further monitoring and reporting are required to identify trends over time to evaluate the effectiveness of various management strategies and investment.

The Audit is developing a web-based system, Australia's Resources Online, to provide a one-stop shop for information on the 'matters for target' and to make invasive animal information accessible to interested groups and organisations. A national information system for invasive species is also under consideration to facilitate monitoring and reporting of invasive animal information at state and national levels.

Collecting, collating and reporting data on invasive animals consistently across all jurisdictions is an ongoing challenge. If information systems and monitoring and reporting frameworks are improved, and protocols for field-based monitoring and jurisdictional-scale reporting are implemented, better information will be available to support decision making and funding initiatives. Future assessments will allow analysis of trends, which can be used to evaluate the effectiveness of management activities and government NRM initiatives.

Introduction

Invasive animals have adverse impacts, or the potential to cause adverse impacts, on social, environmental and economic assets and values. In Australia, invasive animals are a major problem and cause in excess of one billion dollars damage each year (McLeod 2004, Tracey et al 2007). The impacts of many species are largely unknown, and new species are also being introduced. This booklet summarises the current information available to report against ecologically significant invasive species (vertebrate pests), one of the 'matters for target' agreed to under the National Natural Resource Management Monitoring and Evaluation Framework (National M&E Framework) (see Appendix 1).

Nationally consistent information on the extent, abundance and impacts of invasive animals is essential for managing Australia's natural resources and for addressing the problems caused by invasive animals to agriculture, the environment and society. Consistent information on invasive animals also assists in the management of other natural resource themes, including rivers and wetlands, vegetation and weeds.

Foxes (*Vulpes vulpes*) occur in all states and territories of Australia and prey on native wildlife, newborn lambs and poultry (photo courtesy of the Invasive Animals CRC).

The National Land & Water Resources Audit ('the Audit') works with a series of national coordination committees to further the development and implementation of indicators for natural resource management (NRM) programs. The national coordinating committee for the ecologically significant invasive species (vertebrate pests) 'matter for target' is the Australian Vertebrate Pests Committee (VPC). The VPC provides coordinated policy and planning solutions to issues related to animal pests. The VPC operates in accordance with terms of reference defined by the Natural Resources Management Standing Committee and reports through the Natural Resource Policies and Programs Committee. The VPC comprises representatives from the Australian states and territories, the Australian Government, the New Zealand Government and the Australian Commonwealth Scientific and Industrial Research Organisation (Table 1).

Building on existing information is a fundamental part of improving the management of invasive animals and natural resources in Australia. Past initiatives to report on invasive animal species provide a baseline for current reporting at state and national levels. In most cases, information has been collated at the state level using methods comparable across states (eg the Queensland Government's annual pest surveys, and surveys and monitoring conducted in New South Wales and Western Australia). Other initiatives have been coordinated at a national level, such as those reported in *Pest Animals in Australia: A Survey of Introduced Wild Mammals* (Wilson et al 1992) and *Landscape Health in Australia* (NLWRA 2001).

The National M&E Framework builds on the achievements of these initiatives, allowing the capture of more detailed information using a standardised method for important invasive animal species throughout Australia.

Table 1 Agencies represented on the National Coordinating Committee — the Australian Vertebrate Pests Committee (VPC)

Jurisdiction	Agencies represented on the VPC
ACT	Environment ACT
NSW	Department of Primary Industries
NT	Department of Natural Resources, Environment and the Arts
Qld	Department of Primary Industries and Fisheries
SA	Department of Water, Land and Biodiversity Conservation
Tas	Department of Primary Industries and Water
Vic	Department of Sustainability and Environment
WA	Department of Agriculture and Food
Australian Government	Department of Agriculture, Fisheries and Forestry Department of the Environment, Water, Heritage and the Arts CSIRO
New Zealand Government	Ministry of Agriculture and Forestry

CSIRO = Australian Commonwealth Scientific and Industrial Research Organisation

National indicators

The National M&E Framework identifies two indicators for ecologically significant invasive species under the heading 'extent and impact of selected ecologically significant invasive vertebrate species' (Box 1).

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Box 1 Ecologically significant invasive species (vertebrate pests) indicators

The two indicators recommended by the VPC for monitoring and reporting under the National M&E Framework are:

- distribution and abundance of significant invasive vertebrate pests (indicator 1)

- impacts of significant invasive vertebrate pests (indicator 2).

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The VPC and the Audit Advisory Council (AAC) endorsed the indicators; however, the monitoring protocol for the second indicator is being trialled.

The VPC, in collaboration with the states and territories, will further develop this indicator (see Figure 1).

To manage invasive animals and their impacts effectively requires accurate information and products to address management priorities. Monitoring, evaluating and reporting can provide meaningful information to target invasive animal management problems. In particular, national data on invasive animals are required to prioritise investment, measure the effectiveness of funding programs, evaluate the effectiveness of management programs, and report the status of invasive animals against other natural resource themes.

To report on invasive animals and evaluate the effectiveness of management interventions at a national scale requires:

- consistency across all state and territory jurisdictions in monitoring and reporting

- uniformity in the scale of information being measured and reported within and across state and territory jurisdictions.

Figure 1 The stages of development, endorsement, agreement and implementation of national indicators
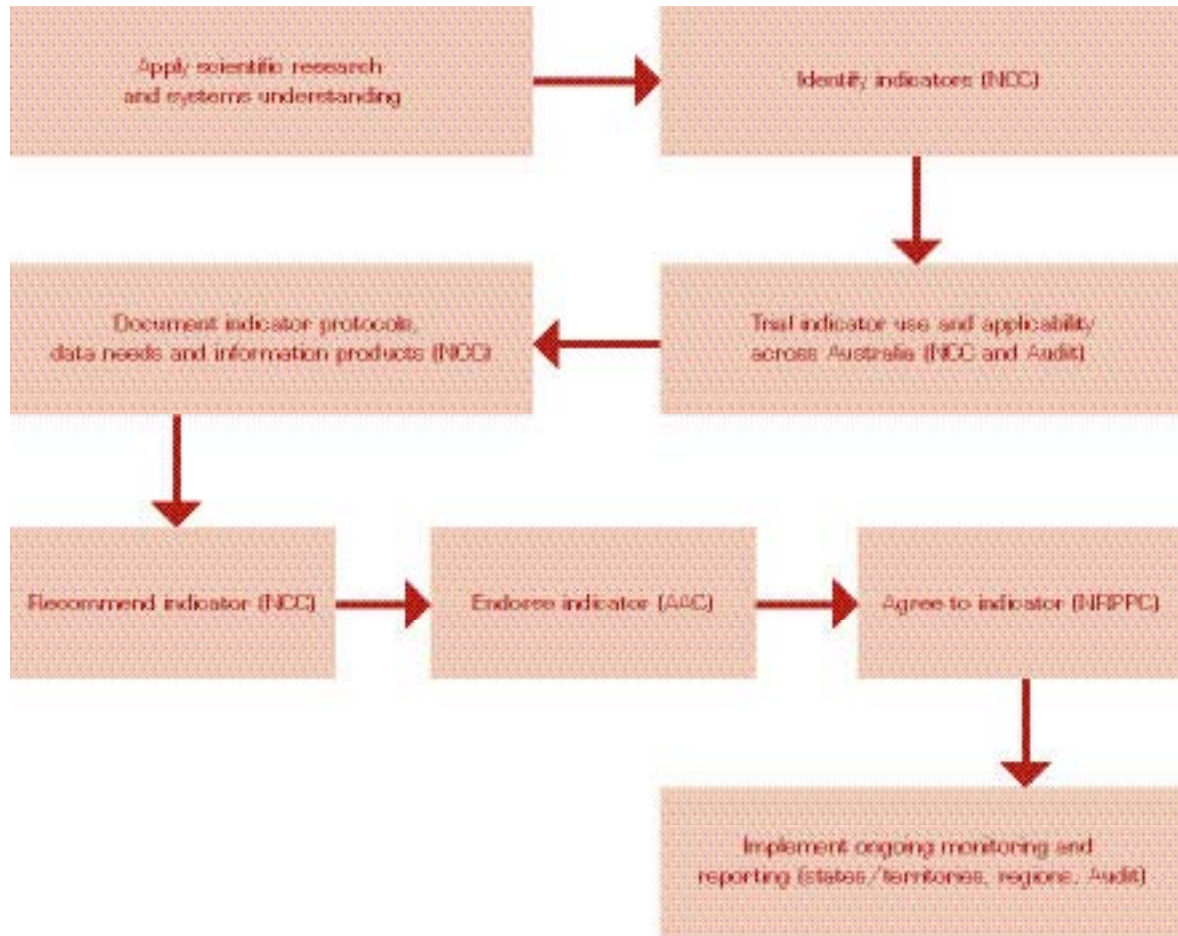
AAC = Audit Advisory Council; NCC = National Coordinating Committee; NRPPC = Natural Resource Policies and Programs Committee

Why is monitoring of these indicators critical in the management of invasive animals?

The two indicators provide fundamental information on the status of invasive animals and their impacts at a national level. Distribution and abundance information provides a means to assess the scale of problems, as well as identify priority areas for funding and investment, evaluate management strategies and coordinate necessary control. Information on the distribution and abundance of invasive animals can be collected at local, regional, state and national levels using relevant techniques and procedures.

Invasive animal impact information is also needed by decision makers and management authorities. Management activities need to be assessed in terms of their effectiveness at reducing invasive animal impacts, and adjusted accordingly to deliver the desired outcomes. Due to difficulties often associated with measuring and reporting impacts at state and national scales, local and regional-scale monitoring is usually a more feasible approach.

The indicators complement each other by providing a combination of distribution and abundance information (measured on a state and national scale) and corresponding impact information (measured on a localised and regional scale). Thus, monitoring these indicators simultaneously provides information needed to:

- identify priorities for immediate and future management planning

- evaluate previous management activities (eg the response of pests to control)

- improve understanding and knowledge about pest numbers and their impacts

- raise awareness of current and potential problems, and opportunities for prevention and control.

Screenshot of the National Land & Water Resources Audit website for Vertebrate Pests

Indicator data needs

An initial assessment of data needs by the Audit identified the density and damage caused by invasive animals as fundamental information to report under the National M&E Framework (Beaten Track Group 2004). The specific questions, for which consistent information is required on an Australia-wide basis, to address these needs and manage invasive animal species are:

- What areas are affected by invasive animals and what is the density of animals in these areas?

- What are the impacts of invasive animals?

Indicator 1 — distribution and abundance

The key questions addressed by the indicator 'distribution and abundance of significant invasive vertebrate pests' are:

- Where are the areas affected (and potentially affected) by invasive animals?

- What is the relative abundance of invasive animals in these affected areas?

These questions are challenging to address because invasive animals are rarely confined by administrative boundaries and are often highly mobile — giving them the capacity to spread into new areas, and move throughout landscapes in response to fluctuations in localised conditions.

Feral pigs (*Sus scrofa*) pose a major threat to biodiversity, cause land degradation, and can act as vectors of exotic disease (photo courtesy of the NSW Department of Primary Industries).

To answer the key questions, and address changes over time, the VPC recommended that the following information would be required at a minimum reporting scale of a 0.5 degree grid (equivalent to approximately 50 km × 50 km):

Occurrence The presence status of a species within an area (ie present, absent or unknown)

Distribution A measure of spatial pattern throughout an area (ie localised or widespread)

Abundance   A measure (in numbers or relative value) of density within a defined area (ie occasional, common or abundant)

Trend   A measure of change in animal abundance over time for the area in question (ie increasing, stable, decreasing or unknown)

Data quality   A measure of data quality associated with the majority of information used to determine overall classification (ie low, medium or high)

The VPC nominated 10 nationally significant invasive animal species for monitoring and reporting under the National M&E Framework, with the intention of addressing additional species and species of jurisdictional importance in the future (Appendix 2).

In the past, state and territory authorities have used a diverse range of methods to measure and report information on invasive animal populations. As a result, information from state and territory government agencies and relevant non-government organisations varies in currency, scale, quality and reliability. Table 2 shows the average scale of original data from state and territory jurisdictions, which have been collated to develop national datasets for the distribution and abundance of invasive animals. Where little data were available, state-wide distribution and abundance information was rapidly collected and collated to facilitate reporting; some data may require further verification.

Uniform monitoring of invasive animals across Australia and consistent reporting processes make it easier for stakeholders to assess the effectiveness of management strategies and investment programs at all levels. Figure 2 presents a concept diagram showing how local and regional data were consolidated to supply state and national datasets.

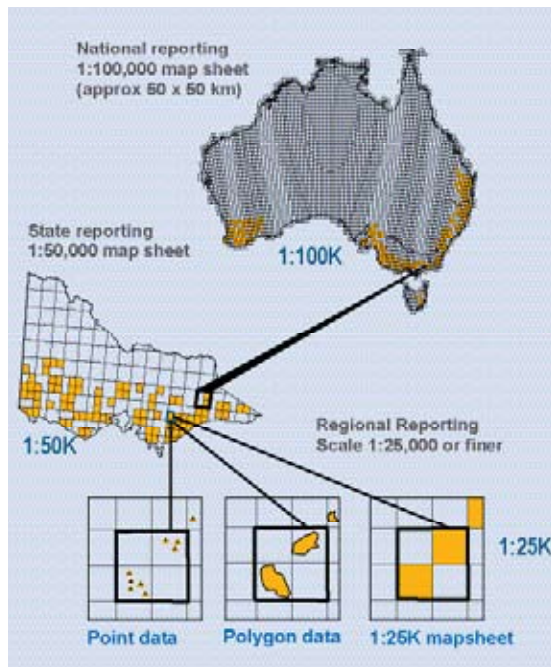**Table 2 Approximate average resolution of best-available state and territory-based data collated to develop national datasets for the distribution and abundance of invasive animals**

Jurisdiction	ACT	NSW	NT	Qld	SA	Tas	Vic	WA
Original data resolution	5 km grid	5 km grid	1:100 000	17 km grid	1:100 000	1:25 000	1:25 000	Property scale

Figure 2 Consolidating local, regional, and state/territory information to report at the national level

National reporting
1:100,000 map sheet
(approx 50 x 50 km)

1:100K

State reporting
1:50,000 map sheet

1:50K

Regional Reporting
Scale 1:25,000 or finer

1:25K

Point data   Polygon data   1:25K mapsheet

Source: NLWRA (2008)

Indicator 2 — impacts

Measuring and monitoring the damage caused by invasive animal species is often a difficult task because the impact varies by species, region, asset type, season and local circumstances. Impact monitoring can also be prohibitively expensive, particularly across large areas. However, information on invasive animal impacts is critical to prioritise management activities, evaluate previous management programs and assess the effectiveness of investment programs.

The key question addressed by this indicator is:

- What are the impacts (and potential impacts) of invasive animals in Australia?

To answer this question, the VPC recommended that information would be required on the impacts of invasive animals (measured in terms of environmental, economic and social impacts) reported at selected areas from existing management programs.

For areas where broadscale information cannot be obtained, or is too expensive to obtain, information can be collected at the local scale, particularly where impact monitoring is a component of existing programs.

Feral cats (*Felis catus*) inhabit about 99% of Australia and are significant predators of native fauna (photo by K Gillett).

As an interim measure, the VPC recommended the use of case studies from established programs that can compile accurate and detailed information on the impacts of invasive animals.

To provide a representative assessment of impacts, monitoring and reporting should address many species, incorporate a variety of impact types, use comparable techniques and cover a range of regions. Techniques for monitoring some of the impacts of invasive vertebrate pests can be found in *Monitoring Techniques for Vertebrate Pests* (Mitchell and Balogh 2007).

The VPC recommended that case studies should include four components:

1. Project summary, problem definition and project location.

2. Monitoring methods, objectives, techniques and analysis.

3. Impact types and the level of environmental, economic or social damage.

4. Current findings, trends and implications.

Assessing Invasive Animals of Australia 2008 (NLWRA and IA CRC 2008) presents a number of impact case studies provided from existing programs and management activities, and a series of the distribution and abundance maps of invasive animals in Australia to report against these indicators.

Data availability and gaps

Availability and gaps in fundamental information are discussed here in terms of:

- data needed to effectively report on the indicators under the National M&E Framework

- measuring the extent of invasive animals and their impacts

- monitoring over time to measure change and report trends in indicators.

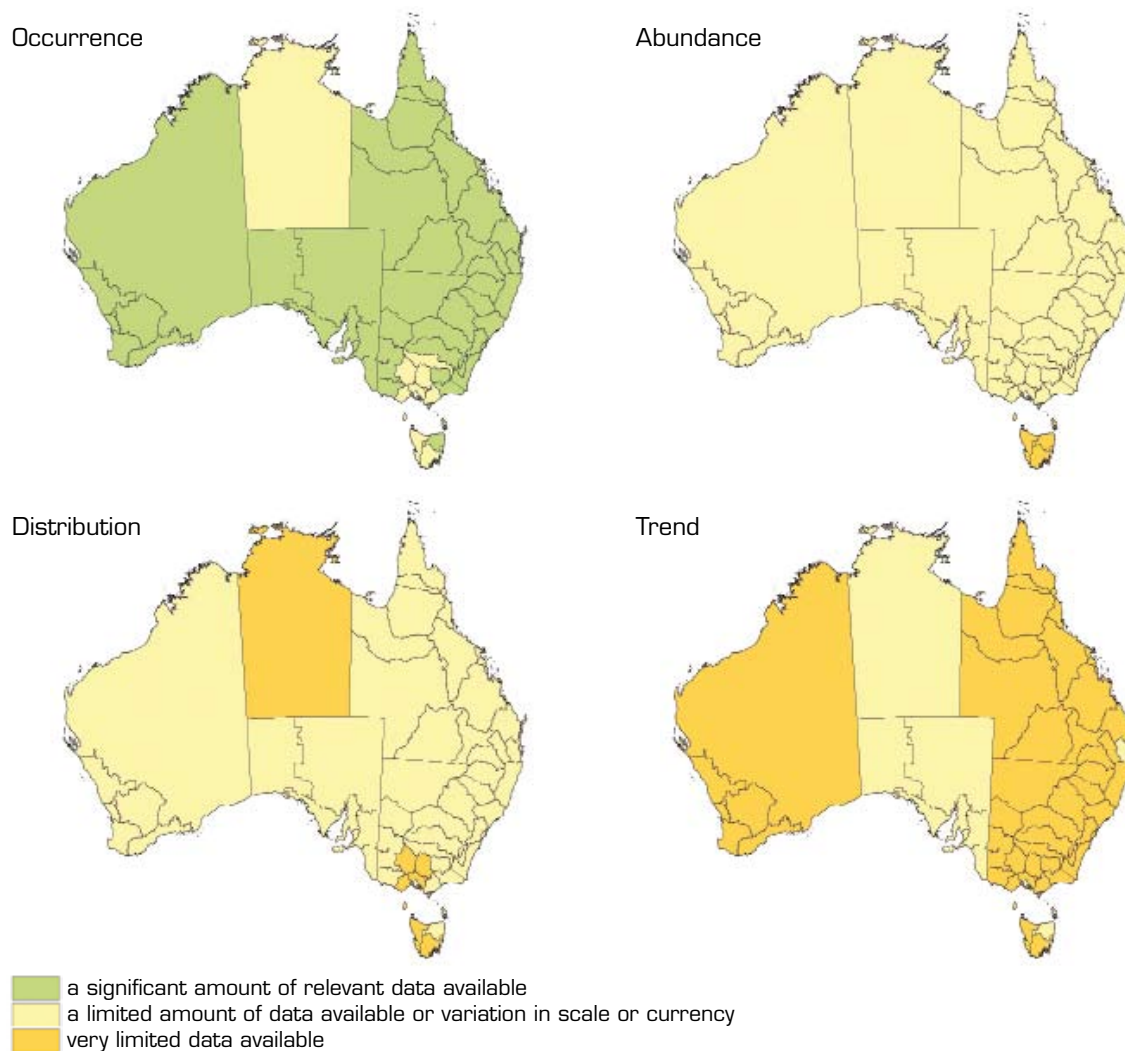## Indicator 1 — distribution and abundance

Available information for reporting on the distribution and abundance of invasive animals varies substantially by species, state and scale. In some cases, important datasets have been collected using differing methods (eg aerial surveys versus local knowledge), resulting in varying levels of reliability and comparability between regions. Some datasets have been collected on an annual basis (eg Queensland), while others have been collected over many years. Invasive animal populations are dynamic and usually change in response to management activities, climatic conditions (particularly rainfall) and local circumstances, so monitoring activities need to be ongoing and sufficiently sensitive to detect changes in pest populations.

The invasive animal species currently addressed under the National M&E Framework are generally well established throughout Australia. For these species, most jurisdictions have reasonable levels of information on species occurrence, but often limited information on abundance, distribution and trends (see Figure 3). A more coordinated government NRM monitoring program is required to report on these fundamental attributes.

The VPC has recommended that, in future, new and emerging pest species should be included within the National M&E Framework. Little information is currently available for most new and emerging species, so a concerted effort to collect data is required by all governments, particularly because these species are often at low numbers.

Figure 3 Data availability within NRM regions for reporting under the National M&E Framework for 10 established vertebrate pests

Occurrence

Abundance

Distribution

Trend

- a significant amount of relevant data available
- a limited amount of data available or variation in scale or currency
- very limited data available

Indicator 2 — impacts

The impacts and damage caused by invasive animals have negative environmental, economic and social consequences. Information on impacts is useful to identify where pest management is required and to assess the effectiveness of various management strategies, control activities, policies, plans and programs. However, information on invasive animal impacts is often difficult to measure and evaluate accurately, particularly across large areas. Animal abundance has been used as a surrogate measure of impacts, despite uncertainties about the relationship between animal population density (ie abundance) and damage.

Most information on the impacts of invasive animals in Australia has been derived from state government monitoring and management programs (such as Southern Ark in Victoria), and monitoring by regional bodies and land-holders to determine when to undertake control. These are often collected on a local and regional scale, and may be included in future impact reporting under the National M&E Framework. Information from land-holder monitoring may be less readily available, except where it is accessible through national land-holder surveys and agricultural census surveys coordinated by the Australian Bureau of Statistics.

A number of research organisations have also delivered information about invasive animal impacts, including statements about the national costs of invasive animals such as *Counting the Costs: Impact of Invasive Animals in Australia* (McLeod 2004). Other research has produced estimates of the impacts of invasive animals at a jurisdictional scale, such as *The threat posed by pest animals to biodiversity in New South Wales* (Coutts-Smith et al 2007). Further assessments are needed.

Modelling predictions of invasive animal impacts can also provide valuable insight into the effects of invasive animals where direct and precise measurements are not easily obtainable.

Information from several sources has formed the basis of the impact case studies reported in *Assessing Invasive Animals of Australia 2008* (NLWRA and IA CRC 2008), which are summarised in Table 3.

For ongoing monitoring and reporting activities under the National M&E Framework, impact information may be obtained through:

- management programs coordinated by state and territory governments

- various research and collaborative research programs (eg the Invasive Animals Cooperative Research Centre)

Table 3 Invasive animal impact case studies

Jurisdiction	Case study
National	National valuation of costs of 11 invasive animal species
	Impacts of invasive animals on national environmental assets and biodiversity
NSW	Threat posed by invasive animals to biodiversity
	Fox predation impacts on threatened shorebirds
Qld	Feral pig predation impacts to nesting threatened sea turtles
	Feral pig damage to banana and sugarcane production
SA	Rabbit impacts on native vegetation and regeneration
Vic	Fox predation impacts on native fauna
WA	Introduced predator impacts on native fauna

- surveys by the Australian Bureau of Statistics (eg the biennial survey Natural Resource Management on Australian Farms)

- monitoring and evaluation activities of the various state governments and NRM regional bodies.

At present, there is no formalised framework for monitoring of invasive animal impacts to assist state-wide and national reporting through the National M&E Framework. There are many techniques that have been developed for measuring the impacts of various species, and a number of monitoring protocols and guidelines have been developed for impact monitoring. However, the impacts of invasive animal

Predation by foxes (*Vulpes vulpes*) is a key threatening process to biodiversity conservation under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (photo by Clive Marks).

species vary considerably by species and impact type, and current protocols may not necessarily deliver comparable information. Thus, there is a need for the development of tools and techniques to provide consistent information for monitoring and reporting under the National M&E Framework. In some instances, the costs associated with measuring the impacts of invasive animals can exceed the benefits from acquiring that information; thus, caution is required with impact monitoring.

Improvements for indicator reporting

All jurisdictions have agreed that the National M&E Framework is fundamentally important for organising the information required for reporting on program evaluation and resource condition. Priorities for monitoring and reporting on invasive animals include:

- review and improvement of monitoring protocols for distribution and abundance

- development of better measures of invasive animal impacts that address current and evolving information needs

- inclusion of additional information to allow assessment of management actions towards resource condition targets

- improved linkages with existing management programs.

Information for reporting on invasive animal impacts under the National M&E Framework is largely limited to a series of case studies that present information on the impacts of various species from monitoring and management programs, or research. An impact monitoring framework for invasive animals that links all available information on impacts, including previous and current research, management activities, case studies, modelling and monitoring activities, is recommended to fulfil the National M&E Framework's reporting requirements.

The following improvements are required to ensure accurate monitoring and reporting on invasive animals under the National M&E Framework:

- development of effective tools and techniques to monitor and report the impacts of invasive animals in a consistent way

- inclusion of new and emerging species, and additional established species, in ongoing monitoring activities

- stronger links with existing management and monitoring programs that assess their effectiveness by measuring invasive animal impacts

Cane toads (*Bufo marinus*) currently occupy about 20% of Australia and have rapidly spread across northern Australia in recent years (photo by Liz Poon).

Common carp (*Cyprinus carpio*) mainly occur in the Murray-Darling Basin, and can represent most of the fish biomass in rivers (photo by John Gasparotto).

- further monitoring to identify how animal numbers influence damage to various assets, and across regions

- an impact monitoring framework that uses core data attributes (to promote consistency in monitoring), draws on existing local-scale monitoring programs and reports key findings.

Management authorities should ensure that precontrol and postcontrol monitoring of invasive animal impacts is a requirement of funding and control activities.

Significant providers of management information

A number of organisations and initiatives may be able to provide information to address the information gaps listed above. Two government initiatives identified to address the management information gaps are listed below.

Australian Bureau of Statistics surveys

National information on the costs of controlling invasive animals is available from the Australian Bureau of Statistics biennial survey *Natural Resource Management on Australian Farms*. This survey

commenced in 2004–05 and collects information on natural resource management issues (including invasive animals and their management) from agricultural establishments throughout Australia. It has gathered information on pest species, control activities, costs of pest management by land-holders, invasive animal impacts and proportion of land impacted. Reporting from the biennial survey is expected every two years.

Government NRM initiatives

Information on investments in research and control is available from previous government-funded NRM activities and may be obtained from future government NRM initiatives.

The Australian Government has previously funded programs to help local communities undertake important on-ground environmental activities, including the control of invasive animals to protect environmental assets. Projects funded through these initiatives show where investment (through control) is allocated. Comparing investment data with national distribution, abundance and impacts information may reveal whether funding is targeted to the correct areas and whether funding goals are being reached.

Funding to research and develop techniques to control invasive animals may also be obtained from the National Feral Animal Control Program (NFACP). The NFACP annually funds projects that aim to develop improved approaches to control the impacts of invasive animals, improve the effectiveness of control techniques, and produce guidelines for managing nationally significant invasive animals. Linking relevant NFACP funding activities with abundance and impacts information may reveal priorities for funding, and could be used to identify whether funding is being allocated to areas and issues that are the most important on a national scale.

Data and information products

Monitoring of invasive animal distribution, abundance and impacts can be used to generate a variety of information products that address the requirements of relevant regional, state, territory and national groups, particularly policymakers, natural resource managers, research groups and industry.

Indicator 1 — distribution and abundance

Products that can be developed from multiple lines of evidence for the indicator 'distribution and abundance of significant invasive vertebrate pests' include:

- regional, state, territory and national maps for the occurrence, abundance, distribution, trend in abundance and data quality for invasive animal species (see Figure 4)

- tabular data defining the total area occupied by each species in each density class

- multiple species maps, which show all species (or groups of species) at national, state jurisdictional, Interim Biogeographic Regionalisation for Australia (IBRA), grid and NRM regional levels (see Figure 5)

- maps of the extent and abundance of pest species, with and without land tenure for management planning, prioritisation and coordination of on-ground management activities.

Composite products that combine information on a species' distribution and abundance with information on a species' impacts (wherever available) may also be highly useful.
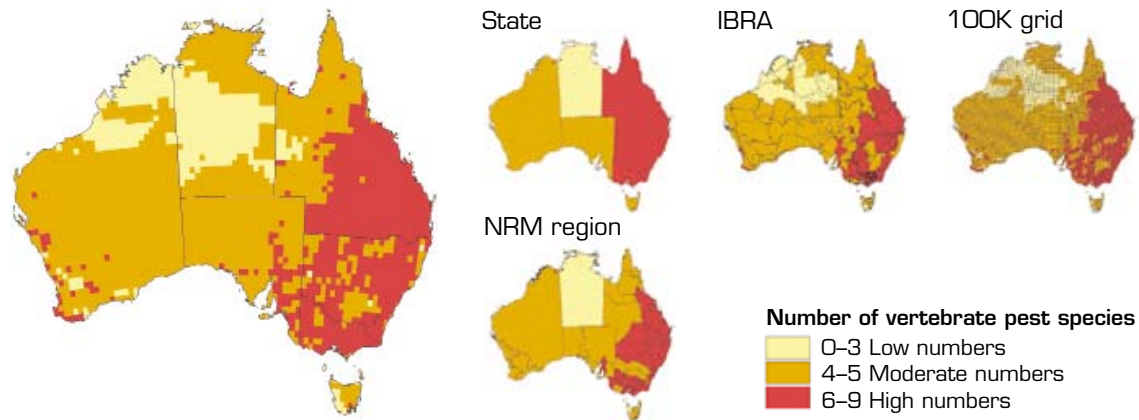
Figure 4 Example information products for feral pigs
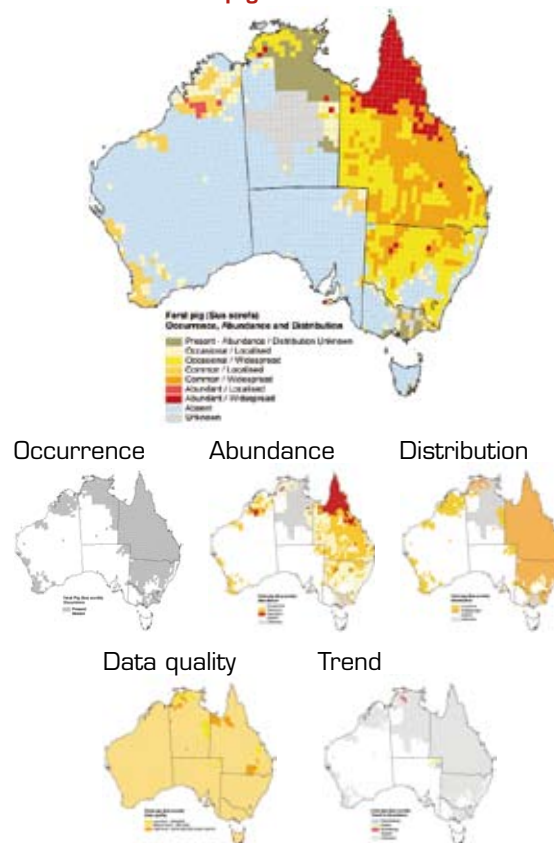
Source: NLWRA and IA CRC (2008)

Figure 5 Example information products for reporting of vertebrate pest species (number of species present) at national, state and territory, IBRA, grid and NRM regional levels

State   IBRA   100K grid

NRM region

Number of vertebrate pest species
- 0–3 Low numbers
- 4–5 Moderate numbers
- 6–9 High numbers

Indicator 2 — impacts

Products that can be developed from the indicator 'impacts of significant invasive vertebrate pests' include:

- case studies reporting the impacts of species on various scales

- graphical information reporting how management actions reduce species' impacts (see Figure 6)

- figures (depending on data availability) showing the cost–benefits of management actions in reducing pest impacts.

Impact information can also be combined with information on a species' distribution and abundance to address management questions, prioritise or evaluate management decisions, and assess the effectiveness of management policy (see Figure 7).

Data and information systems

A number of systems and products are available that could provide information related to the ecologically significant invasive species indicators. Although they do not report directly on the indicators, these systems and products can provide multiple lines of evidence

Figure 6 Example information product, breeding success of little terns at sites with and without fox control
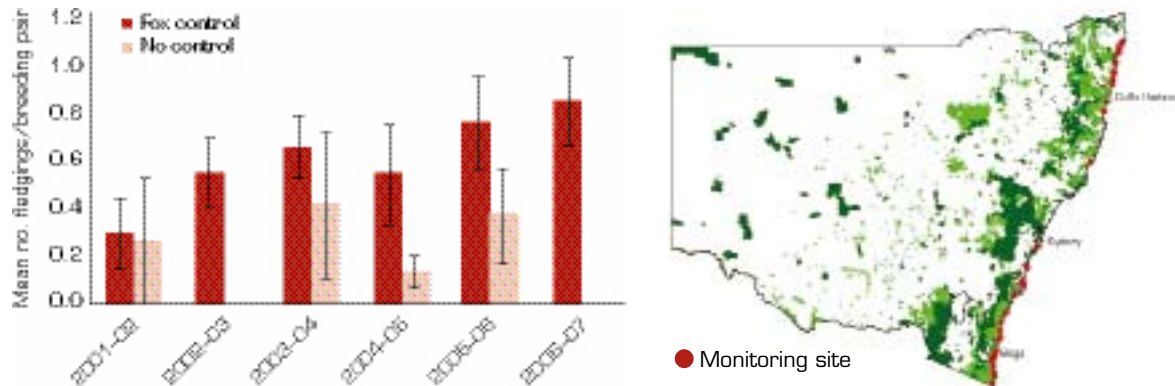
Source: NSW Department of Environment and Climate Change, in NLWRA and IA CRC (2008)

when evaluating progress against the matter for target and the effectiveness of management actions.

Australian Natural Resources Data Library

The Australian Natural Resources Data Library[1] provides a range of spatial data and information online. Information is available in a number of formats, including reports. The Data Library provides a link to datasets that contain information on themes, including invasive vertebrate pests. Spatial data from current and future assessments will be available for download from the library for a range of purposes.

[1]   http://adl.brs.gov.au/anrdl

Figure 7 Example information product, abundance of feral pigs against density of environment assets — Matters of National Environmental Significance
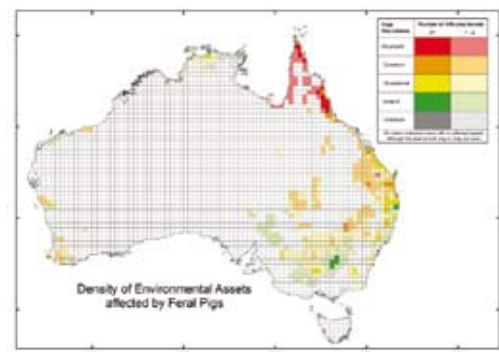
Source: Department of the Environment, Water, Heritage and the Arts, in NLWRA and IA CRC (2008)

Australian Natural Resources Atlas and Australia's Resources Online

The Australian Natural Resources Atlas[2] will hold assessment information related to invasive species and will allow access to reports, map-making tools and Australia's Resources Online (ARO). ARO is a new component of the Atlas being developed by the Audit for ongoing reporting on the National M&E Framework indicators. ARO will contain maps of the extent and abundance of invasive animal species of national significance and regional-based statistics on the area containing each species.

Screenshot of Australia's Resources Online website

National information system for invasive species

A national information system (or a component of an existing national information system) dedicated to managing invasive species information is under consideration. Many state and territory governments have developed information systems to manage, store, manipulate and report information on invasive species (see Table 4). A review of existing government information systems is needed to evaluate their practicality for addressing invasive species monitoring and reporting needs.

Arrangements for ongoing data and information management regarding invasive animal distribution, abundance and impact information are needed between the Australian Government and respective state and territory jurisdictions.

The new biosecurity application for Australia, called BioSIRT (Biosecurity, Surveillance, Incident Response and Tracing), is a national information system for routine and emergency management. While some components are still under development, BioSIRT may provide a platform for monitoring and reporting of invasive animal information with consistency and reliability.

A combination of the Australian Natural Resources Data Library, ARO and a future national information system for invasive species information would provide the requirements for monitoring and reporting under the National M&E Framework.

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2   http://www.anra.gov.au/aro

Table 4 State and territory information systems and data attributes

Jurisdiction	Information system	Records	Stand alone / networked	Comments
NSW	Pest Database	Plants	Stand alone	
	Pest Animal Survey 2006	Animals	Stand alone	
NT	Territory Weeds Database	Plants	Stand alone	
	Pest Animal Database	Animals	Stand alone	
Qld	PestInfo 4.2	Plants/animals	Stand alone	
	APDS	Plants/animals	Stand alone	
SA	Pest2000+	Plants/animals	Stand alone	
	PIMS	Plants/animals	Networked (internet based)	In early planning stage
Tas	GT-Spot	Animals	na	Currently being phased out
	Natural Values Atlas	Animals	Networked (internet based)	Pest recording not yet incorporated
Vic	IPMS	Plants/animals	Networked	
	EIS	Native and pest plants and native animals; on-ground environmental management actions	Networked	
WA	CRIS	Plants/animals	Networked (intranet based)	
	Weed Watcher	Plants	Networked (internet based)	
	Vertebrate Pests Survey 2005	Animals	Stand alone	

na = not available
Source: Modified from Paping (2006)

Discussion and way forward

The Audit, Invasive Animals Cooperative Research Centre, collaborating agencies and the VPC have implemented methods and protocols for collation of fundamental information on invasive animals and their impacts throughout Australia. The current capacity to report on the significant invasive species (vertebrate pests) 'matter for target' under the National M&E Framework can be summarised as follows:

■ Indicator data for the distribution and abundance of invasive animals vary throughout Australia, but jurisdictions have implemented national standards and collated nationally consistent datasets. Regional NRM organisations have been engaged in development of these datasets and need to be incorporated further in future activities.

■ Indicator data for the impacts of invasive animals are largely available from existing management programs through case studies. Improvements are required to develop and adopt a more advanced impact-monitoring methodology to allow consistent reporting across regions and jurisdictions.

Feral goats (*Capra hircus*) are found in all states and territories, and can withstand extended dry periods (photo by Robert Henzell).

■ Indicator protocols need to be reviewed periodically to ensure they are applicable, and to ensure improvements to procedures (eg reporting scale) and techniques are incorporated.

■ Information gaps have been identified and improvements have been recommended for future monitoring and reporting activities.

■ Information products need to be further developed and tested to ensure they meet the requirements of decision makers and continue to represent the status of invasive animals in Australia.

- A national information system for invasive animals needs to be developed and adopted to ensure vital information on populations and their impacts is available for managers, decision making, policy and the development of effective control strategies.

- Arrangements are required for data and information management between governments.

- Assets under threat (or potentially under threat) of invasive animals need to be identified in order to prevent or control impacts.

An ongoing commitment through government NRM programs is needed for monitoring and reporting invasive animal populations and their associated impacts. Some refinement to monitoring procedures will facilitate more accurate reporting in future activities, and improved measurements of impacts are required for assessing the effectiveness of management decisions.

The next national assessment on invasive animals should occur within two to three years, and should support concurrent state-level reporting frameworks and the national *State of the Environment Report* due in 2011. Along with information to report on the current indicators for invasive animals, it should report on:

- additional established species of jurisdictional significance, and new and emerging species (and the scale of incursions)

- national, state and territory investments in invasive animal control

- management activities and the area of active invasive animal management

- control costs (incorporating annual control costs by regions)

- environmental, economic and social assets to be protected

- impacts of invasive animals on respective assets.

Appendix 1 The National Monitoring and Evaluation Framework

The National Natural Resource Management Monitoring and Evaluation Framework (referred to in this series as 'the National M&E Framework') was endorsed by the Natural Resource Management Ministerial Council in 2002. It was developed to assess progress towards improved natural resource condition through the development of accurate, cost-effective and timely information on:

■ the health of Australia's land, water, vegetation and biological resources

■ the performance of programs, strategies and policies that provide national approaches to the conservation, sustainable use and management of these resources.

Assessment of information collated under the National M&E Framework will assist the Ministerial Council to 'identify areas of concern and to better target the use of resources'.

The framework identifies three key requirements for monitoring natural resource condition:

1. a set of natural resource condition indicators (including those for the 'matters for target' identified in the National Framework for Natural Resource Management Standards and Targets) to measure progress towards agreed national outcomes on a medium and long-term basis

2. a set of indicators for monitoring community and social processes relevant to or affected by NRM programs, as well as measures of the adoption of sustainable development and production techniques

3. contextual data pertinent to the indicator being considered.

The National Land & Water Resources Audit ('the Audit') is responsible for ongoing development of these indicators, as well as supporting the national collection and collation of data, and reporting against each indicator.

Such reporting will help to answer questions such as:

- What is the nature and extent of the issue?

- Is the existing or proposed intervention appropriate for the size of the issue?

- What types of intervention work best, are most cost effective, and have the best transferability across regions?

- What was the impact of the policy or program investment — in the intermediate and long term?

Monitoring and evaluation of core indicators supports evidence-based decision making at national, state and territory, and regional levels. However, each level may have a wide variety of data and information needs, in terms of content, context or scale. There is also complexity across the three levels of use associated with multiple needs, values, preferences and timeframes.

Feral pigs inhabit about 45% of Australia, and are a major agricultural and environmental pest (photo by Brendan Cowled).

Appendix 2 Invasive animal species to be monitored under the National M&E Framework

Invasive animal species identified as of national significance for monitoring under the National M&E Framework are listed below.

Species	
Cane toads	*Bufo marinus*
Common carp	*Cyprinus carpio*
Common starlings	*Sturnus vulgaris*
Feral cats	*Felis catus*
Feral goats	*Capra hircus*
Feral pigs	*Sus scrofa*
Foxes	*Vulpes vulpes*
Rabbits	*Oryctolagus cuniculus*
Wild dogs and dingoes	*Canis lupus familiaris, Canis lupus dingo* and hybrids
Deer species	
Chital	*Axis axis*
Fallow	*Dama dama*
Hog	*Axis porcinus*
Red	*Cervus elaphus*
Rusa	*Cervus timorensis*
Sambar	*Cervus unicolour*

Additional species for consideration in future activities under the National Monitoring and Evaluation Framework are listed below. Note that this list is subject to approval by respective authorities and is a guide only at this stage.

Species	
Banteng	*Bos javanicus*
Buffalo	*Bubalus bubalis*
Feral camels	*Camelus dromedaries*
Feral donkeys	*Equus asinus*
Feral horses	*Equus caballus*
House mouse	*Mus domesticus*
Indian myna birds	*Acridotheres tristis*
Indian palm squirrels	*Funambulus pennanti*
Red-eared slider turtles	*Trachemys scripta elegans*
Pest fish species	
Black mangrove cichlid	*Tilapia mariae*
Eastern gambusia	*Gambusia holbrooki*
Mosambique tilapia	*Oreochromis mossambicus*
Oriental weather loach	*Misgurnus anguillicaudatus*
Roach	*Rutilus rutilus*
Rosy barb	*Puntius conchonius*
Tench	*Tinca tinca*

Glossary

Abundance	A measure (in numbers or relative value) of animal population density in a defined area.
Distribution	A measure of spatial pattern or dispersion of a species throughout a defined area.
Emerging species	Any new or emerging species whose distribution, abundance and impacts are likely to be significant.
EPBC	The *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act) is the Australian Government's central piece of environmental legislation.
Established population	A population that is self sustaining through reproduction or immigration and has survived in a location for a period of time.
Impact	An adverse consequence of a pest species, often classed as social, environmental, or economic.
Invasive species	A species occurring as a result of human activities beyond its acceptable normal distribution and which threatens valuable environmental, agricultural and personal resources by the damage it causes (Beeton et al 2006).
Occurrence	Presence of a species within a defined area.
Pest animal	Any native or introduced, wild or feral, non-native species of animal that is currently troublesome locally, or over a wide area, to one or more persons, either by being a health hazard, a general nuisance, or by destroying food, fibre, or natural resources (Koehler 1964).
Regions and subregions	The Interim Biogeographic Regionalisation for Australia (IBRA) defines 85 bioregions and 404 subregions for assessing the status of native ecosystems, use in monitoring and evaluation, and assessing current natural resource management initiatives.

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About the 'Status of Natural Resource Information' series

This series of booklets outlines the status of data and information relating to indicators agreed under the National Natural Resource Management Monitoring and Evaluation Framework (2002). Each booklet describes the status of coordination, indicators, information management systems, and data and information products for a particular theme area.

- Estuarine, coastal and marine
- Inland aquatic (wetlands)
- Land salinity
- Land use
- Native vegetation

- Significant invasive species (vertebrate pests)
- Significant invasive species (weeds)
- Social and economic information
- Soil condition