



Appendix 1 Protocol for monitoring distribution and abundance

Monitoring Protocol — Distribution and abundance (*abbreviated version*)

Matter for target

Ecologically significant invasive species

Indicator heading

Extent and impact of selected ecologically significant vertebrate invasive species

Indicator

Distribution and abundance of significant invasive vertebrate pests

This protocol presents the recommended monitoring method for collecting, collating and reporting information on the distribution and abundance of significant invasive vertebrate pests at national, state or territory and regional levels. It is to be used in conjunction with the indicator protocol for *Impacts of Significant Invasive Vertebrate Pests*.

Methodology

Monitoring should be undertaken using the techniques appropriate for local-scale monitoring and developed into state-scale datasets using the following procedure. It should be applied to develop data at a minimum scale of 0.5-degree reporting units (equivalent to 1:100 000). Monitoring should be coordinated annually for new incursions of species (at a resolution of at least 1:25 000), two to three years for emergent species, and four to five years for established species. Data-aggregation procedures are needed to convert state data for national reporting. A series of national, state or territory and regional distribution and abundance maps will be produced from the data to reveal trends throughout Australia.

This methodology has been modified from the Queensland Government Department of Natural

Resources and Water Annual Pest Distribution Survey, and New South Wales Department of Primary Industries state-wide survey methodology.

Step 1 Species occurrence

This criterion has the highest level of accuracy.

The occurrence of a pest should be recorded as:

- *present* — species exists in the defined area
- *absent* — species does not exist in the defined area
- *unknown* — it is not known (or participants are unsure) whether the species exists.

Step 2 Distribution — spatial pattern

When the presence is confirmed, the distribution of the species (incursion or spread of a species) within the defined area can be recorded as:

- *localised* — species occurs in a clumped pattern and occupies less than 50% of a cell
- *widespread* — species occurs in most areas and occupies greater than 50% of a cell.

Distribution provides a useful indication of the size of infestations; however, its accuracy is influenced by the survey participant's varying perception of populations and the difficulty of assessing large areas of land. This criterion has a lower level of accuracy than 'occurrence'.

Step 3 Abundance — relative numbers

Abundance refers to the relative density of a species within an area and can be described as:

- *occasional or low* — animals spaced at wide intervals, or few or no sightings and/or little active evidence (eg very infrequent observations or little evidence of animals and tracks, scats and other traces)

- *common or medium* — a middle measure between occasional and abundant, or some animals seen at almost any time and/or much sign of activity (eg frequent observations or some evidence of animals and tracks, scats and other traces)
- *abundant or high* — infestations that have reached their full potential and provide little opportunity for additional animals to survive in that area, or many animals seen at any time and much sign of activity (eg very frequent observations or much evidence of animals and tracks, scats and other traces).

Abundance is particularly difficult to estimate because the participant's perception of abundance levels can vary with species; species detection varies between habitat types; and some habitats support higher concentrations of species, depending on environmental conditions.

Step 4 Trend

Trend refers to the change in animal abundance over time using anecdotal information where trends cannot be obtained and is recorded as:

- *increasing* — populations have increased in abundance over the previous five years
- *stable* — populations have remained stable in abundance over the previous five years
- *decreasing* — populations have decreased in abundance over the previous five years
- *unknown* — no information available.

Trend is particularly useful for measuring a change in populations over time, but this criterion only has a moderate level of accuracy.

Step 5 Data quality

Data quality and reliability should be reported using the following classification:

- *no data* — no information about data quality
- *low* — anecdotal information from ad hoc sources and incidental reports; no reliable expert knowledge or survey data; equates to 'low level' or 'anecdotal'
- *medium* — expert opinion from local specialists providing general knowledge based on observations and other sources, such as control activities; equates to 'little data'
- *high* — scientific data from recognised field-sampling protocols, field surveys, systematic sampling or formal assessment; equates to 'some data and expert opinion'.

Data quality is particularly useful for verifying the accuracy of information for interpretation and analysis.



Appendix 2 Protocol for monitoring impacts

Monitoring Protocol — Impacts (*abbreviated version*)

Matter for target

Ecologically significant invasive species

Indicator heading

Extent and impact of selected ecologically significant vertebrate invasive species

Indicator

Impacts of significant invasive vertebrate pests

This document presents the recommended monitoring protocol for collecting, collating and reporting information on the impacts of significant invasive vertebrate pests at the national, state or territory and regional levels. This protocol is to be used in conjunction with the indicator protocol for *Distribution and Abundance of Significant Invasive Vertebrate Pests*.

'Impacts' are any detrimental consequence of invasive animals on environmental, economic and social values, assets and services in a defined area. Information on impacts is required to assess the effectiveness of management strategies and control programs.

This indicator protocol recommends collecting accurate and detailed information on the impacts (social, environmental and/or economic) of pest species at selected areas to present valuable information for decision makers at all levels. Where broad-scale information on the impacts of invasive animals is not easily obtainable or is cost prohibitive, monitoring should be undertaken at selected areas and reported through case studies to supply information on pest impacts. Reporting should be undertaken from a series of studies using comparable techniques across species, impact types and regions. A series of techniques for monitoring the impacts of invasive animals can be found in Mitchell and Balogh (2007).

Guidelines for invasive animal impact case studies

1. **Project summary** — includes project name, definition of the problem, pest species, pest abundance, location, management program, lead agency or agencies, project duration, monitoring variables, and a site description.
2. **Monitoring methods** — includes a description of the monitoring objectives and variables measured (eg measurements of impact); a description of survey techniques; a statement about sampling and experimental design (sample size; frequency; replicates; transects and design); control activities associated with monitoring; and any data calculations and analysis performed to deduce results.
3. **Results** — includes a summary of the results of the monitoring regarding the impacts of invasive animals on economic, social and/or environmental assets (including figures, tables and images as necessary). This section should address the main impacts identified; the level of impact (quantitative or qualitative damage such as loss of production, species/habitats/ecosystem services affected, social costs, and any relevant information); a description of the impacts relative to animal density; and a description of potential impacts.
4. **Outcomes** — describes the outcomes in regard to management, trends regarding previous monitoring, and implications for industries and environments. A link should be provided to relevant publications, reports, websites and other studies.

Appendix 3 Summary of pest species data

	NSW	Qld	ACT	Vic	Tas	SA	NT	WA
Feral pigs	NSW Pest Animal Survey 2004–2006; expert knowledge	APDS 2006; expert knowledge	NSW Pest Animal Survey 2004–2006; expert knowledge	Atlas; State of Parks reports; expert knowledge	NVA; wildlife surveys; regional workshops; expert knowledge	Regional animal control boards; expert knowledge; previous survey maps	NT aerial surveys; expert knowledge	Pest Animal Survey; regional workshops; expert knowledge
Feral goats	NSW Pest Animal Survey 2004–2006; expert knowledge	APDS 2006; expert knowledge	NSW Pest Animal Survey 2004–2006; expert knowledge	Atlas; State of Parks reports; expert knowledge	NVA, wildlife surveys; regional workshops; expert knowledge	Regional animal control boards; expert knowledge; previous survey maps	NT aerial surveys; expert knowledge	Pest Animal Survey; regional workshops; expert knowledge
Feral deer	NSW Pest Animal Survey 2004–2006; expert knowledge	APDS 2006; expert knowledge	NSW Pest Animal Survey 2004–2006; expert knowledge	Atlas; State of Parks reports; expert knowledge	Aerial and spotlight surveys; regional workshops; expert knowledge	Regional animal control boards; expert knowledge; previous survey maps	na	Pest Animal Survey; regional workshops; expert knowledge
Rabbits	NSW Pest Animal Survey 2004–2006; expert knowledge	APDS 2006; expert knowledge	NSW Pest Animal Survey 2004–2006	Atlas; IPMS; State of Parks reports; expert knowledge; control records	NVA; annual spotlight surveys; regional workshops; expert knowledge	Regional animal control boards; expert knowledge; previous survey maps	Expert knowledge	Pest Animal Survey; regional workshops; expert knowledge
Feral cats	NSW Pest Animal Survey 2004–2006; expert knowledge	APDS 2006; expert knowledge	NSW Pest Animal Survey 2004–2006; expert knowledge	Atlas; State of Parks reports; expert knowledge	NVA; annual spotlight surveys; regional workshops; expert knowledge	Regional animal control boards; expert knowledge; previous survey maps	Expert knowledge	Expert knowledge
Wild dogs	NSW Pest Animal Survey 2004–2006; expert knowledge	APDS 2006; expert knowledge	NSW Pest Animal Survey 2004–2006; expert knowledge	Atlas; PAIS; State of Parks reports; expert knowledge	NVA; regional workshops; expert knowledge	Regional animal control boards; expert knowledge; previous survey maps	Expert knowledge	Pest Animal Survey; regional workshops; expert knowledge

	NSW	Qld	ACT	Vic	Tas	SA	NT	WA
Foxes	NSW Pest Animal Survey 2004–2006; expert knowledge	APDS 2006; expert knowledge	NSW Pest Animal Survey 2004–2006; expert knowledge	Atlas; IPMS; State of Parks reports; expert knowledge; control records	Fox database; expert knowledge.	Regional animal control boards; expert knowledge; previous survey maps	Expert knowledge	Pest Animal Survey; regional workshops; expert knowledge
Cane toads	NSW Pest Animal Survey 2004–2006; NSW DECC survey; Frog Rescue Service; expert knowledge	Qld cane toad database	na	na	na	na	Cane toad database; expert knowledge	na
Common starlings	NSW Pest Animal Survey 2004–2006; Birds Australia surveys/ database	Birds Australia surveys/ database	NSW Pest Animal Survey 2004–2006; Birds Australia surveys/ database	Atlas; State of Parks reports; expert knowledge	NVA; regional workshops; expert knowledge	Birds Australia surveys; expert knowledge; SA Ornithologists Association	Birds Australia surveys; expert knowledge	Field surveys; expert knowledge
Common carp	NSW Pest Animal Survey 2004–2006; NSW DPI database; expert knowledge	Fisheries database	NSW Pest Animal Survey 2004–2006; NSW DPI database; expert knowledge	Atlas; State of Parks reports; expert knowledge; Fisheries data	Inland Fisheries Service database; expert knowledge	SARDI database; expert knowledge	na	Department of Fisheries database

NSW = New South Wales; Qld = Queensland; ACT = Australian Capital Territory; Vic = Victoria; Tas = Tasmania; SA = South Australia; NT = Northern Territory; WA = Western Australia

APDS = Annual Pest Distribution Survey; Atlas = Atlas of Victorian Wildlife Records; DECC = Department of Environment and Climate Change; DPI = Department of Primary Industries; IPMS = Integrated Pest Management System; na = not applicable; NVA = Natural Values Atlas; PAIS = Pest Animal Information System; SARDI = South Australian Research and Development Institute



Appendix 4 National guidelines for data aggregation

National guidelines for data aggregation (*abbreviated version*)

Introduction

The development of national datasets for mapping the extent, abundance and distribution of invasive species using a 0.5-degree tile (standard 1:100 000 map sheets) has been endorsed by the Australian Weeds Committee and the Australian Vertebrate Pests Committee. This supports the National Land & Water Resources Audit's role to coordinate the collation of data against resource-condition indicators and develop nationally linked information systems.

A number of jurisdictions produce invasive-species data that are stored as point, line, polygon and raster data at various scales (eg 0.125 degrees or 1:25 000 and 0.5 degrees or 1:50 000) as part of routine monitoring and reporting activities. Thus, these data need to be aggregated or generalised for national reporting based on 1:100 000 map sheets while maintaining their thematic characteristics and integrity. To ensure consistency, national guidelines have been developed to outline rules for the aggregation of tiled data.

This paper identifies the agreed rules used to aggregate invasive species data for national reporting. Although there is no perfect solution to data aggregation, these rules are considered to be workable.

Definitions

Occurrence relates to the 'presence' status of a particular species within an area — whether it is present, absent or unknown (ie no data available or the area has not been assessed). When additional information is available, the 'presence' class of occurrence can be described further in terms of distribution and abundance (see below). For example, occurrence information based on presence or absence is used to determine the extent of a weed in a tiled reporting framework.

Distribution relates to the spatial pattern or dispersion of species over an area (eg widespread or localised, unknown or nil within a given area).

Abundance relates to the number of individuals of a species. In a quantitative situation it might be a count (eg 100) or range (eg 100–150), whereas in a subjective situation, it might be high, medium or low.

Density is a measure of abundance per unit area. In a quantitative situation, it might be 100 per square kilometre or 100–150 per square kilometre. However, in a subjective situation, and for the purposes of reporting state or territory and national data in map format, it could be represented as a combination of abundance and distribution (eg abundant and widespread, or occasional and localised).

Trend is defined as the change in occurrence, distribution, abundance or data quality over time. Trend is classified as increasing, stable, decreasing or unknown.

Data aggregation rules

Aggregation rules have been generated for:

- **Occurrence** — present, absent or unknown
- **Distribution** — localised, widespread, unknown or nil
- **Abundance** — occasional, common, abundant, unknown or nil
- **Data quality** — high, medium, low or unknown
- **Trend** — increasing, stable, decreasing or unknown.

Assumptions

Point, line, polygon or raster data are compiled in a fine map sheet grid (eg 1:25 000 or 1:50 000) that then requires aggregation for reporting at 1:100 000. Data will be aggregated directly from the finest input grid directly to the 1:100 000 grid and not through a stepped process such as 1:25 000 through 1:50 000 through to 1:100 000.

Occurrence (present, absent or unknown)

- Present — species occurs in the tile
- Absent — species does not occur in the tile
- Unknown — status is unknown.

Source data	Aggregated value
Present for any tile	Present
Absent for all tiles	Absent
Any combination of absent/unknown	Unknown

Distribution (localised, widespread, unknown or nil)

Distribution within the aggregated tile is based on Occurrence records of source tiles:

- Localised — individuals are located within less than half the area
- Widespread — individuals are dispersed over more than half the area
- Unknown — distribution is not known
- Nil — species does not occur.

Aggregation rules for distribution need to be undertaken in numerical order.

Distribution number 1 (Dbn1) — more than 25% of source tiles are Occurrence: Unknown and aggregated tile is Distribution: Unknown

Dbn2 — if all of the known remaining tiles are Occurrence: Absent, the aggregated tile is Distribution: Nil

If rules Dbn1 or Dbn2 are not met, then the following rules apply if there is at least one Occurrence: Present recorded (Present comes from Occurrence data).

Dbn3 — if less than 25% of source tiles are Occurrence: Present, the aggregated tile is Distribution: Localised

Dbn4 — if greater than or equal to 25% of source tiles are Occurrence: Present, then

- (a) if the greatest distance between Occurrence: Present in both x and y directions is greater than 50% of the total distance of x and the total distance of y, then the aggregated tile is Distribution: Widespread
- (b) if the greatest distance between Occurrence: Present in either the x or y direction is less than or equal to 50% of the total distance of x or y, then the aggregated tile is Distribution: Localised.

Data quality aggregation

Data quality classes are based on the National Land & Water Resources Audit report classes:

- **3** — based on reliable data
- **2** — little measured data
- **1** — derived without investigation through expert opinion
- **0** — no data available.

Data quality is aggregated by calculating the average of the source tiles. If the average is less than a source data class, it is assigned to the lower class.

Trend aggregation

- Increasing — an increasing number of individuals
- Stable — the number of individuals remains steady
- Decreasing — a declining number of individuals
- Unknown — the trend is not known.

Trend is aggregated by calculating the average of the source tiles, where increasing = 3, stable = 2 and decreasing = 1. Where the average calculation is between two trend categories, it can be assigned to the higher class. Note that this will result in an overestimate.

Acknowledgments

This report represents a culmination of work undertaken during the implementation of the national invasive animals work plan, and collaboration between the National Land & Water Resources Audit, the Invasive Animals Cooperative Research Centre, all states and territories, and the Australian Vertebrate Pests Committee. We are grateful to the Australian Government sponsor agencies: Department of the Environment, Water, Heritage and the Arts and the Department of Agriculture Fisheries and Forestry for ongoing support.

The following organisations directly contributed to the implementation of the national invasive animals work plan: Victorian Department of Sustainability and Environment, Department of Primary Industries, and Parks Victoria; New South Wales Department of Primary Industries, and Department of Environment and Climate Change; South Australian Animal and Plant Control Group of the Department of Water, Land, and Biodiversity Conservation; Queensland's Department of Natural Resources and Water; the Department of Agriculture and Food Western Australia, and Western Australian Department of Environment and Conservation; Northern Territory Natural Resources, Environment and the Arts; Tasmanian Department of Primary Industries and Water; Environment ACT; and the Indigenous Lands Corporation.

Various local governments, regional natural resource management groups, research bodies and community groups also contributed to the collation of information for this report. The Australian Vertebrate Pests Committee and Bureau of Rural Sciences provided significant guidance and ongoing recommendations.

A number of individuals directly contributed to the implementation of the work plan and the Assessment, in particular Blair Wood, Chris Auricht, Valerie Wayte, Martine Franco, Peter Wilson, Quentin Hart and Jim Thompson. The project would not have been possible without contributions from Elaine Murphy, Glen Saunders, Simon Veitch, Lucy Randall, Leanne Brown, Mary Bomford, Peter Fleming, Simon Bennett, Jason Alexandra, Frank Keenan, Moya Calvert, Paul Paping, Terence Chen, Tony Pople, Marc Bryant, Mark Ramsay, Mark Williams, Greg Mutze, Anne Dennis, John Burley, Jim Backholer, Naomi Wilson, Damian Collopy, Damian Shepherd, Andrew Woolnough, John Asher, Greg Beeston, Barry Kay, Rob Williamson, Paul Mahon, Andrew Leys, Robyn Delaney, Keith Saalfeld, Glenn Edwards, Nick Mooney, Roger Wickes, Jessica Gibson, Scott McArdle, Julian Barraclough and Denise Fowler. Thank you to those who provided recommendations for the report and to those who supplied supporting images.

Glossary

Abundance

A measure (in numbers or relative value) of density in a defined area.

Acclimatisation societies

Societies created in order to enrich the fauna of a region with animals and plants from around the world.

Alien species

Belonging to a foreign country; animals that have been intentionally or accidentally introduced as a result of human activities.

Biocontrol

Control of pests by disrupting their ecological status through the use of organisms that are natural predators, parasites or pathogens.

Biodiversity

Variability among living organisms from all sources (including terrestrial, marine, and other ecosystems and ecological complexes of which they are part), which includes diversity with species and between species and diversity of ecosystems (Beeton et al 2006).

Caring for our Country

Australian Government natural resource management initiative, commencing July 2008.

Critically endangered

As defined in and listed under the EPBC Act, a native species is eligible to be included in the critically endangered category at a particular time if, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.

Distribution

A measure of spatial pattern or dispersion throughout a defined area.

Ecological community

An assemblage of species occupying a particular area.

Emerging species

Any newly established vertebrate species whose distribution, abundance and impacts are likely to be significant.

Endangered species

As defined in and listed under the EPBC Act, a native species is eligible to be included in the endangered category at a particular time if, at the time, (a) it is not critically endangered; and (b) it is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria.

Eradication

Application of measures to eliminate a species from a defined area.

Established population

A population that is self-sustaining through reproduction or immigration and has survived in a location for a period of time.

Exclosure

Area fenced to keep unwanted animals out.

Exotic species

A species that originates from a foreign country; an imported species that only occurs in captivity.

Feral species

Species of an introduced animal with an established self-sustaining population in the wild.

Hybrid

A crossbreeding between related species or subspecies.

Impact of pest species

An adverse consequence of a pest species, often classed as social, environmental, or economic.

Introduced species

A non-native species that was intentionally or unintentionally brought into an area by humans.

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).

Key threatening process

A process that threatens or may threaten the survival, abundance or evolutionary development of a native species or ecological community.

Matters of national environmental significance

Matters of national environmental significance include internationally important wetlands, nationally listed threatened species and ecological communities, listed migratory species, the Commonwealth marine environment, world heritage properties, national heritage places, and protection of the environment from the impact of nuclear actions.

Occurrence

Presence of a species within a defined area.

Pest animal or species

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, bioregions and subregions

There are 56 regions to facilitate the integrated delivery of natural resource management priority issues. The Interim Biogeographic Regionalisation for Australia also 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.

Threat abatement plan

Plan providing for the research, management and any other actions necessary to reduce the impact of a listed 'key threatening process' on a threatened species or ecological community.

Threatened species

A species listed under the EPBC Act as critically endangered; endangered; vulnerable; or conservation dependent.

Vulnerable

As defined in and listed under the EPBC Act, a native species is eligible to be included in the vulnerable category at a particular time if, at that time (a) it is not critically endangered or endangered; and (b) it is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.

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On-line resources

National Land & Water Resources Audit:
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