

## 4 Impacts of significant invasive vertebrate pests

This chapter summarises the main outcomes of the collection, collation and reporting of impacts information throughout Australia to report under the indicator, 'Impacts of significant invasive vertebrate pests' (see Chapter 2). Information has been compiled from management programs that directly or indirectly monitor and report the impacts of invasive animals on environmental, economic and social values.

The economic, environmental and social impacts of invasive animals in Australia have been estimated at one billion dollars per year (McLeod 2004, Tracey et al 2007). However, this is considered a conservative estimate and there are many gaps in our knowledge on impacts. The cumulative effects of invasive species are particularly difficult to measure and report; thus, the real impact cost of invasive pest animals is likely to exceed this value.

Invasive animals are known to threaten many of Australia's Matters of National Environmental Significance, including Threatened Species and Ecological Communities, and Listed Migratory Species (eg little terns), Marine Species and Environments (eg grey-headed albatross on Macquarie Island), and Wetlands of International Importance (eg Macquarie Marshes Ramsar wetland in NSW). They are listed in the top three greatest threats to threatened species and ecosystems, riparian environments and important wetlands of Australia (Tait 2005), and are a major threat in almost all World Heritage Areas in Australia.

These threats range from cane toads in Kakadu, rabbits on Macquarie Island to feral pigs in the wet tropics. Their significance is duly reflected in the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act), where invasive animals represent 7 (41%) of the 17 listed 'key threatening processes' for nationally listed threatened biodiversity.



Foxes prey on the nests of many freshwater turtles, such as the eastern long-necked turtle (*Chelodina longicollis*) at Jervis Bay (photo by Paul Meek)

### Measuring and monitoring impacts

Measuring and reporting the impacts of pests usually require detailed sampling of a number of attributes. The types of impacts caused by invasive animals include: damage to water quality and runoff, changes to soil structure and erosion, alteration of plant species composition and biomass, damage to crops and production systems, changes in animal populations and production, spread of human and livestock disease, change in ecosystem structure, and species extinction (Hone 1994).

At present, many invasive animals are listed under state and Commonwealth threatened species legislation as 'key threatening processes' because of their impacts on environmental and biodiversity values. Some species are also recognised as a serious threat for exotic disease maintenance and transmission; for example, if diseases such as foot-and-mouth disease were introduced to Australia.



Rabbit warrens encourage weeds and soil erosion (photo by NSW Department of Primary Industries)

Measurements of impacts often involve direct counts of damage, indirect assessments such as questionnaire surveys, extrapolations from experiments to field conditions, and modelling predictions. Other techniques can be applied to measure the impacts of pests in the field. These range from visual scoring of crop damage to monitoring prey populations before and after pest-control activities.

The impacts of invasive animals are widespread, varied and significant throughout Australia. Many of the impacts are poorly quantified and poorly presented for decision making at the various levels of management. Improved information regarding the impacts of pests is required to allow decision makers to manage pests effectively. Information on pest impacts is particularly important at the local scale to decide how much control to implement to reach a desired goal and to decide what level of impact by a pest is considered 'acceptable'.

## How does monitoring help in the management of invasive animals?

Monitoring is an essential part of invasive animal management and can include simultaneous monitoring of pest numbers and pest impacts.

Monitoring the impacts of a pest is fundamental to:

- identify priorities for immediate and future management (eg planning and resource allocation)

- evaluate previous management activities (eg the response of pests to control)
- improve understanding and knowledge (eg the relationship between pest numbers and their impacts)
- raise awareness and provide education on current and potential problems, as well as opportunities for prevention and control.

## Case studies of impacts

This Assessment has addressed the issue of reporting the impacts of invasive animals by selecting a series of projects that have measured impacts directly using field-sampling techniques.

The following is a set of observations from research and management projects that provide information on the impacts of invasive animals in Australia.

The protocol for measuring the '*Impacts of significant invasive vertebrate pests*' is under development by the Australian Vertebrate Pests Committee (VPC). The finalised protocol is anticipated to recommend techniques for consistent monitoring of the impacts of invasive animals, to provide consistency in data collection and reporting Australia-wide. Until such time as a protocol is developed and endorsed by VPC and adopted, VPC has agreed that the most effective way to report the impacts of invasive animals is by using a series of selected studies that present information about the impacts of pests in Australia. Referred to hereafter as case studies, this approach was chosen because there is presently no single agreed consistent method for measuring and reporting all the different types of impacts associated with invasive animals. They vary between species and different assets (environmental, economic and social). Damage also typically varies between locations and at different times or seasons (Hone 2007).

The current Assessment uses these case studies to monitor the trends in impacts over time and in future assessments. In most instances, the case studies have been sourced from management and monitoring programs that have a range of objectives,

including the control of pests, but these programs can be used simultaneously to report the impacts of pests. Measuring and reporting impacts is generally resource demanding, and varies by species, region and the type of impact, eg damage to wine grapes by common starlings.

The case studies have been selected to report the impacts of invasive animals from a range of species and various impact types and locations, and these case studies use existing pest management programs wherever available.

The following two objectives were addressed for impact reporting through case studies:

- to present an overview of impacts of significant invasive vertebrate pests throughout the regions of Australia across social, economic and environmental themes
- to provide examples of monitoring the impacts of pest species over time to report the effectiveness of various management programs.

The case studies present a series of research findings that identify and report the impacts of various invasive animals in Australia. Ideally, a number of species, impact types and locations should be used to report the impact of all pest species throughout Australia (ie to present an overview of impacts). Because the case studies are also aimed at reporting the impacts of pest species over time and into the future, the chosen studies were selected for their capacity to be included in future assessments. Consequently, some of the case studies cannot present many results in this Assessment, but their results are expected to be included in future assessments.

The following section contains the case studies that were reported from national, state and territory governments to summarise the impacts of invasive animals from the relevant monitoring and management programs for this Assessment. The reporting format of the case studies has followed the guidelines for invasive animal impact case studies (see Appendix 2) wherever suitable. Where this format was unsuitable, an alternative format has been applied.

### Case study 1

#### The threat posed by invasive animals to biodiversity in New South Wales

Adapted from Coutts-Smith, AJ, Mahon PS, Letnic M and Downey PO (2007). *The Threat Posed by Pest Animals to Biodiversity in New South Wales*, Invasive Animals Cooperative Research Centre, Canberra.

In New South Wales (NSW), invasive animals pose a risk to 388 threatened species and communities — representing 40% of threatened biodiversity. They comprise 154 plant species, 186 animal species, 17 threatened populations of plants or animals, and 31 endangered ecological communities.

A further examination of each of these groups, as well as the categories of threat (ie endangered and vulnerable), is presented below.

#### Endangered and vulnerable species

Threatened species in NSW are categorised according to the degree to which they are threatened, using the internationally accepted World Conservation Union Red List classifications of 'endangered' or 'vulnerable'.<sup>12</sup> Invasive animals pose a threat to 38% of all native species listed as endangered and to 42% of species listed as vulnerable in NSW (Coutts-Smith et al 2007). This equates to 26% and 27% of endangered and vulnerable plant species, respectively, and to 77% and 62% of endangered and vulnerable animal species, respectively.

Most of the invasive animal species that pose a threat to biodiversity in NSW can be classified into one of three broad groups: terrestrial predators, terrestrial herbivores, or fish (including all the aquatic alien species). Examination of these major groups of invasive animals revealed that introduced herbivores threaten the highest percentage of species, at 63%, followed by predators at 44%, fish at 7%, and remaining invasive animals at 5% (see Table 4.1). Introduced herbivores pose the main invasive animal threat to endangered and vulnerable plant species, as well as plant populations and ecological communities. Introduced predators pose the main threat to endangered and vulnerable animal species, as well as animal populations (see Table 4.1).

<sup>12</sup> <http://www.iucnredlist.org> (Accessed 15 May 2008)

### Threatened plant and threatened animal species

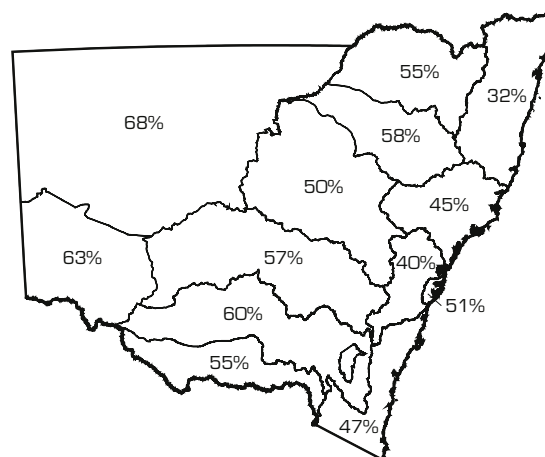
Of the 5248 vascular plant species that occur in NSW, 578 are listed as threatened. Of these, 154 are at risk from invasive animals (see Table 4.2). These figures include algae, aquatic plants and fungi, for which accurate numbers are not available. Dicotyledons are the most frequently identified group of plants at risk, with 122 species threatened by invasive animals. However, as a proportion, monocotyledons are the most at risk with 35% of all threatened monocotyledons at risk from invasive animals (see Table 4.2).

Of the 938 native animals that occur in NSW, 276 are listed as threatened. Of these species, 186 are at risk from invasive animals. This includes 15 threatened fish and invertebrate species at risk from invasive animals, for which accurate numbers are not available (see Table 4.2). Invasive animals pose a threat to two-thirds of the animal species and to 83% of the animal populations listed as threatened in NSW (see Table 4.2). Birds were identified most frequently as being at risk, with 74 species threatened by invasive animals. However, as a proportion, reptiles are the most at risk with 93% of all threatened reptiles at risk from invasive animals (see Table 4.2).

### Threatened plant and animal populations and ecological communities

Invasive animals pose a threat to 83% of the endangered animal populations (see Table 4.2). The types of animal populations at risk include mammals, frogs, fish and birds. In contrast, invasive animals pose

**Figure 4.1 Percentage of threatened species in each natural resource management region at risk from invasive animals in NSW**



Native animals such as the shingleback skink (*Trachydosaurus rugosus*) are vulnerable to predation by foxes and feral cats (photo by Lee Webley)

**Table 4.1 Number of threatened species at risk from the major invasive animal groups in NSW**

Groups of invasive animals	Number of threatened species at risk							Total number and percentage of threatened species at risk	
	Endangered species		Vulnerable species		Populations		Ecological communities	Number	%
	Plant	Animal	Plant	Animal	Plant	Animal			
Predators	0	57	0	95	0	11	7	170	44
Herbivores	89	41	59	21	2	4	28	243	63
Fish	0	12	0	8	0	3	3	26	7
Other alien species	5	4	2	10	0	1	0	20	5
<b>Total</b>	<b>92</b>	<b>76</b>	<b>62</b>	<b>110</b>	<b>2</b>	<b>15</b>	<b>31</b>	<b>388</b>	<b>100</b>

Note: Total values are not cumulative as many threatened species are threatened by more than one group of pest animals.

**Table 4.2 The threat posed by invasive animals to specific groups of threatened species in NSW**

Threatened species	Taxonomic grouping	Number of threatened species examined	Number of threatened species at risk from invasive animals	Percentage of species threatened by invasive animals [%]
<b>Plant species</b>	Algae	1	nr	na
	Aquatic plants	4	1	25
	Dicotyledons	458	122	27
	Ferns and allies	16	1	6
	Fungi	9	nr	na
	Gymnosperms	6	1	17
	Monocotyledons	84	29	35
	Total	578 <sup>a</sup>	154	27
<b>Animal species</b>	Amphibians	27	19	70
	Aquatic invertebrates	3	nr	na
	Birds	114	74	65
	Fish	12	7	58
	Invertebrates	14	8	57
	Mammals	57	39	68
	Marine mammals	7	nr	na
	Reptiles	42	39	93
	Total	276 <sup>b</sup>	186	67
<b>Plant populations</b>		19	2	11
<b>Animal populations</b>		18	15	83
<b>Ecological communities</b>		81	31	38
<b>Total</b>		972 <sup>ab</sup>	388	40

nr = not recorded; na = not applicable

<sup>a</sup> excludes four species for which threats could not be determined, and includes algae, aquatic plants and fungi for which accurate numbers are not available

<sup>b</sup> includes fish and invertebrates, for which accurate numbers are not available

Note: Threatened species refers to all biodiversity listed in Schedules 1 and 2 of the *NSW Threatened Species Conservation Act 1995* and Schedules 4 and 5 of the *NSW Fisheries Management Act 1994*, as at 1 January 2006.

a threat to only 11% of threatened plant populations (see Table 4.2). Invasive animals also pose a threat to 31 endangered ecological communities (as defined by the *Threatened Species Act*<sup>13</sup> and the EPBC Act), or 38% of all endangered ecological communities in NSW.

### Natural resource management regions of New South Wales

All of the 13 natural resource management regions in NSW contain significant proportions of threatened

species at risk from invasive animals, ranging from 32% in the Northern Rivers Catchment Management Authority (CMA) to 68% in the Western CMA (see Figure 4.1).

### Further information

Coutts-Smith AJ, Mahon PS, Letnic M and Downey PO (2007). *The Threat Posed by Pest Animals to Biodiversity in New South Wales*. Invasive Animals Cooperative Research Centre, Canberra.

<sup>13</sup> ecological community means an assemblage of species occupying a particular area

## Case study 2

### National valuation of invasive animal impacts — Counting the costs assessment

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

The economic, environmental and social impact of 11 invasive animal species on Australian agricultural industries and the environment were estimated in a desktop review. The review provided a 'triple-bottom-line' national perspective on the impacts of invasive animals. Species were selected on the basis of relevance to current and potential research activities, and in consultation with research specialists. Cost estimates include pest control and production-loss estimates per year. The environmental impacts of three species were assessed where some data were available. Environmental impact data were lacking for all other species.

The cost of the impact of the 11 species subject to assessment totalled \$720 million per year (see Table 4.3). Foxes, feral cats, rabbits and feral pigs were estimated to account for 82% of losses, of which loss in agricultural productivity accounts for about half of the total costs estimated. Independent research on the impacts of pest birds (Tracey et al 2007) indicates that the overall impacts of invasive animals cost over \$1 billion per year in Australia.

The costs included in the economic impact assessment were:

- costs to control invasive animals including baiting, fencing and shooting, and research associated with improved management of the specific species
- production losses (estimated for sheep, cattle and cropping industries), including: predation on young stock, crop damage and competition for feed
- public sector research and management costs.

The cost assessments included in the environmental impacts were typically based on an invasive animal's impact on biodiversity. Where possible, impacts were quantified in cost terms, although it should be noted

**Table 4.3 Economic, environmental and social costs of impact of pest species (in order of cost) per year**

Triple-bottom-line impacts							
	Total	Economic		Environmental		Social	
	Cost (\$m)	Qualitative impact	Cost (\$m)	Qualitative impact	Cost (\$m)	Qualitative impact	Cost (\$m)
Fox	227.5	**	37.5	**	190.0	*	nq
Feral cat	146.0	*	2.0	**	144.0	*	nq
Rabbit	113.1	**	113.1	*	nq	*	nq
Feral pig	106.5	**	106.5	*	nq	*	nq
Wild dog	66.3	**	66.3	*	nq	*	nq
Mouse	35.6	**	35.6	*	nq	**	nq
Common carp	15.8	*	4.0	**	11.8	*	nq
Feral goat	7.7	*	7.7	*	nq	*	nq
Cane toad	0.5	*	0.5	*	nq	*	nq
Wild horse	0.5	*	0.5	*	nq	*	nq
Camel	0.2	*	0.2	*	nq	*	nq
Total	719.7		373.9		345.8		

\$m = \$ million; \*\* = larger impact; \* = smaller impact; nq = not quantified



The size of a feral pig's home range is determined largely by food availability (photo by Steve Lapidge)

that accurate information relating to ecological cause-and-effect relationships, along with the communities' valuations of species preservation, are not readily available. Environmental valuations were undertaken for feral cat, fox and common carp impacts because data were available for these species.

Many gaps exist in our knowledge of the major environmental and social impacts of invasive animals. These impacts are shown in Table 4.3 for each species in qualitative terms, and where quantitative impact information was readily available it was included.

#### Further information

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

Invasive Animals Cooperative Research Centre<sup>14</sup>

<sup>14</sup> <http://www.invasiveanimals.com> (Accessed 15 May 2008)

### Case study 3

#### Impacts of invasive animals on national environmental assets and biodiversity

The Department of the Environment, Water, Heritage and the Arts (DEWHA) maintains spatial and other information on Matters of National Environmental Significance that are protected under the EPBC Act. These matters include Listed Threatened Species and Communities, Migratory Species, Wetlands of International Significance, and World Heritage Areas and National Heritage Sites. In this analysis, the Matters of National Environmental Significance are referred to as 'environmental assets'.

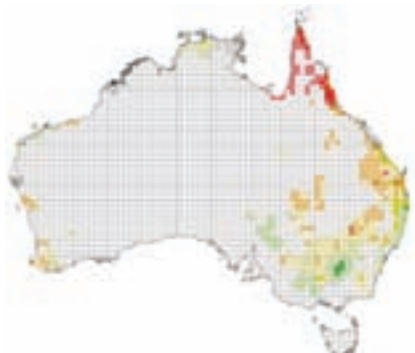
Information available from DEWHA includes distribution maps of each asset, as well as a database that summarises the environmental assets and threats that relate to them. The threats are those explicitly listed in threat abatement plans, recovery plans, management plans, species profiles, listing and conservation advice, and other references. The threats include invasive animals.

DEWHA has developed tools to count the number of environmental assets that are affected by a given threat (eg an invasive animal species) in an area, say a grid cell. From this, continental-scale density maps were compiled of the number of environmental assets affected by that given threat.

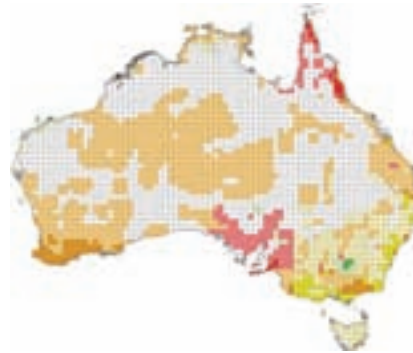
In this illustrative analysis, the asset–threat density maps have been integrated with the distribution and abundance maps for feral pigs, feral goats, rabbits, feral cats and foxes compiled for the current assessment (see Chapter 3). Figure 4.2 shows the number of environmental assets that are identified as being affected by the respective invasive animal species per grid-square area. The areas in red denote high pest abundance coinciding with environmental assets, orange denotes medium pest abundance with environmental assets, and yellow denotes low pest abundance in areas with environmental assets. The green areas indicate that potentially sensitive assets occur where the pest is not yet present, representing priorities for monitoring and opportunities for early eradication should the pest colonise. In the case of

**Figure 4.2 Abundance of invasive animals and the density of affected environmental assets for (a) feral pigs, (b) feral goats, (c) rabbits, (d) feral cats and (e) foxes**

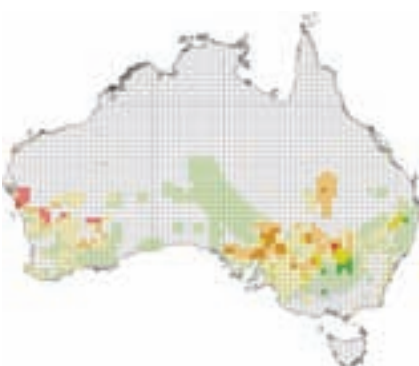
a) Feral pigs and affected environmental assets



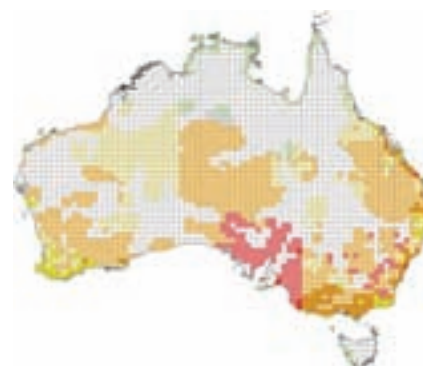
d) Feral cats and affected environmental assets



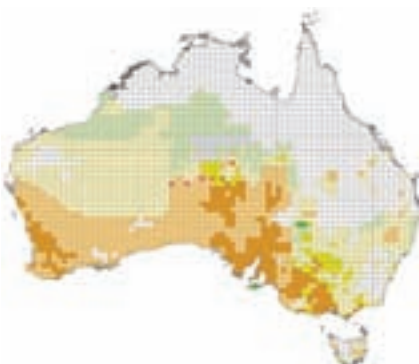
b) Feral goats and affected environmental assets



e) Foxes and affected environmental assets



c) Rabbits and affected environmental assets



Pest Abundance	Number of Affected Assets	
	3+	1-2
Abundant	Red	Light Red
Common	Orange	Light Orange
Occasional	Yellow	Light Yellow
Absent	Green	Light Green
Unknown	Grey	Light Grey

No colour indicates areas with no affected assets, although the pest animal may or may not occur.

Source: DEWHA, 2007

the red fox, the whole of Tasmania should be regarded as a 'green area' because of the potential impact of foxes on susceptible species in Tasmania not covered by this analysis. Only five species were addressed for this analysis.

The compiled data allow for additional analyses to be undertaken, for example to:

- provide lists of the particular assets affected in different areas of a pest range
- produce maps of classes of assets affected by a pest (eg wetlands, critically endangered species, mammals or orchids).

Such analyses have obvious value in assessing assets, threats and priorities for action at a range of spatial scales, and can provide information that can feed into development and application of threat abatement plans and other planning documents.

#### Further information

Department of the Environment, Water, Heritage and the Arts<sup>15</sup>

<sup>15</sup> <http://www.environment.gov.au> (Accessed 15 May 2008)

## Case study 4

### Monitoring feral pig predation on nesting threatened sea turtles in Cape York, north Queensland

#### Project title

Feral pig predation on sea turtle nests in north Queensland

#### Lead agency

Cape York Peninsula Development Association Incorporated, in conjunction with the Department of Natural Resources and Water (now Biosecurity Queensland, Department of Primary Industries and Fisheries) and the Natural Heritage Trust

#### Species

Feral pig (*Sus scrofa*)

#### Location

The study was conducted during summer of 2006–07 at four monitoring sites in north Queensland: three located along the western edge of Cape York and one site on Prince of Wales Island.

#### Monitoring

Turtle nests were identified during beach surveys (see Figure 4.3), and the following parameters were recorded:

- the number of turtle nests disturbed by predators
- the level of predation on turtle nests
- the likely predator species recorded during the specified monitoring period.

#### Impact type

Predation rates at the four sites were calculated from a simple estimate of the percentage of nests disturbed by feral pigs. Threatened sea turtles are

valued by Indigenous groups and tourists, and their decline could have a range of social impacts and ecosystem effects.

#### Current findings

The study found that:

- Feral pigs prey on up to 70% of sea turtle nests in far-north Queensland.
- An average of 35% of sea turtle nests were destroyed by feral pigs and wild dogs.
- Predation rates can reach 100% of nests.
- Feral pig control can reduce predation levels on threatened sea turtle nests.

The results are summarised in Table 4.4.

A continuing high level of predation from feral pigs on turtle nests in the region was observed. Further monitoring is expected to provide long-term impact data.

#### Further information

Biosecurity Queensland, Department of Primary Industries and Fisheries<sup>16</sup>

Figure 4.3 Monitoring sea turtle nest predation in north Queensland



Photo supplied by Biosecurity Queensland.

<sup>16</sup> [http://www.dpi.qld.gov.au/cps/rde/dpi/hs.xml/4790\\_ENA\\_HTML.htm](http://www.dpi.qld.gov.au/cps/rde/dpi/hs.xml/4790_ENA_HTML.htm) (Accessed 15 May 2008)

Table 4.4 Predation rates on sea turtle nests by feral pigs and wild dogs at four sites in far-north Queensland

Sites	Number of nests monitored	Monitoring period (weeks)	Predation rate (%) (number of nests destroyed)	Major predator
Napranum	197	14	65% (128)	Feral pigs
Mapoon	669	15	16% (107)	Wild dogs
Injinoo	210	13	70% (147)	Feral pigs
Prince of Wales Island	15	9	20% (3)	Feral pigs

## Case study 5

### Monitoring feral pig damage to banana and sugar cane production in north Queensland

#### Project title

Monitoring the economic cost of feral pigs to agricultural industries in the wet tropics of Queensland

#### Lead agency

Department of Natural Resources and Water (now Biosecurity Queensland, Department of Primary Industries and Fisheries)

#### Species

Feral pigs (*Sus scrofa*)

#### Location

The study site was the wet tropics of north Qld, particularly the coastal strip and associated highlands near Innisfail.

#### Monitoring

The following parameters were monitored:

- the economic damage caused by feral pigs to sugar cane and banana farms; determined from interviews with land holders and farm inspections between 2000 and 2002
- feral pig control costs
- lost production (and costs)
- an index of pig activity; used as a surrogate for density.

#### Impact type

Feral pigs cause much damage to sugar cane and bananas in Qld (see Figure 4.4). An estimate of the level of damage (in terms of on-farm costs) was supplied by landholders. Damage to crops was also measured during farm inspections in fixed 10 m × 2 m plots. The relationship between the estimates of damage (including control costs and lost production) and pig activity (presence or absence of any pig sign, ie tracks, scats or traces) was combined separately for either banana or cane farms at each survey period and assessed.

#### Current findings

Although information collected is largely specific to the wet tropics region, the study found that:

- Feral pigs caused, on average, direct economic damage of \$1800 per banana farm per year and \$5350 per cane farm per year.
- Feral pigs caused damage to 16 150 tonnes of sugar cane (valued at over \$377 000) or 5.65% of the sugar crop.
- There was no significant relationship between pig activity and the economic damage they caused for either banana or sugar cane farms.
- The total costs of feral pig damage and costs of control averaged \$4100 per year for each banana farm and \$10 600 per year for each cane farm.

#### Further information

Mitchell JL and Dorney W (2002). *Monitoring Systems for Feral Pigs*. Report to the National Feral Animal Control Program, Bureau of Rural Sciences, Canberra.

Biosecurity Queensland, Department of Primary Industries and Fisheries<sup>17</sup>

<sup>17</sup> [http://www.dpi.qld.gov.au/cps/rde/dpi/hs.xsl/4790\\_ENA\\_HTML.htm](http://www.dpi.qld.gov.au/cps/rde/dpi/hs.xsl/4790_ENA_HTML.htm) (Accessed 15 May 2008)

Figure 4.4 Feral pig sow destroyed after damaging sugar cane crops



Photo by Ben Allen

## Case study 6

### Monitoring rabbit impacts on native vegetation and regeneration in the Flinders Ranges, South Australia

#### Project title

Operation Bounceback from the Flinders Ranges and surrounding regions: Impacts of rabbits on native vegetation in the Flinders Ranges

#### Lead agency

Department of Environment and Heritage South Australia, and the Animal and Plant Control Group of Department of Water Land and Biodiversity South Australia

#### Species

Rabbits (*Oryctolagus cuniculus*)

#### Location

Operation Bounceback is an ecosystem recovery project operating in the Vulkathunha-Gammon Ranges National Park, Flinders Ranges National Park and adjoining sheep stations.

#### Monitoring and outcomes

The project involved measuring vegetation response to the following experimental treatments:

- fenced vegetation enclosures
- broad-scale rabbit control.

There were five separate monitoring sites, all located within the broad study area of Operation Bounceback.

#### **Site 1 Mulga enclosures at Arcoona Creek catchment, Vulkathunha-Gammon Ranges National Park**

The number of mulga seedlings (*Acacia aneura*) that germinate after heavy summer rainfall events was measured under rabbit control treatments.

Despite substantial reductions in rabbit densities following the introduction of biocontrol agents, rabbit grazing is still preventing recruitment of mulga and the species is declining. Rabbits have caused 40% mortality in six months (see Figure 4.5).

#### **Site 2 Spidery wattle enclosures at Balcanoona Creek catchment, Vulkathunha-Gammon Ranges National Park**

The spidery wattle (*Acacia araneosa*) is an endemic plant in South Australia that is listed as 'vulnerable' under the EPBC Act and as 'endangered' under South Australian legislation.

The number of spidery wattle that grew beyond seedling size was measured under rabbit control treatments.

Rabbit and feral goat exclusion significantly enhanced recruitment of spidery wattle and resulted in the establishment of a mixed age-class population within the enclosures; plant numbers have increased by 94% where rabbits and goats have been excluded.

#### **Site 3 Gum Creek *Acacia victoriae* shrubland rabbit-control experiment, Flinders Ranges National Park**

The number of perennial plants in quadrats and species composition was measured under rabbit-control treatments.

Rabbit control enhanced recruitment of moderately palatable perennial plants and reduced the weediness of annual vegetation, despite substantially increased compensatory grazing by other herbivores.

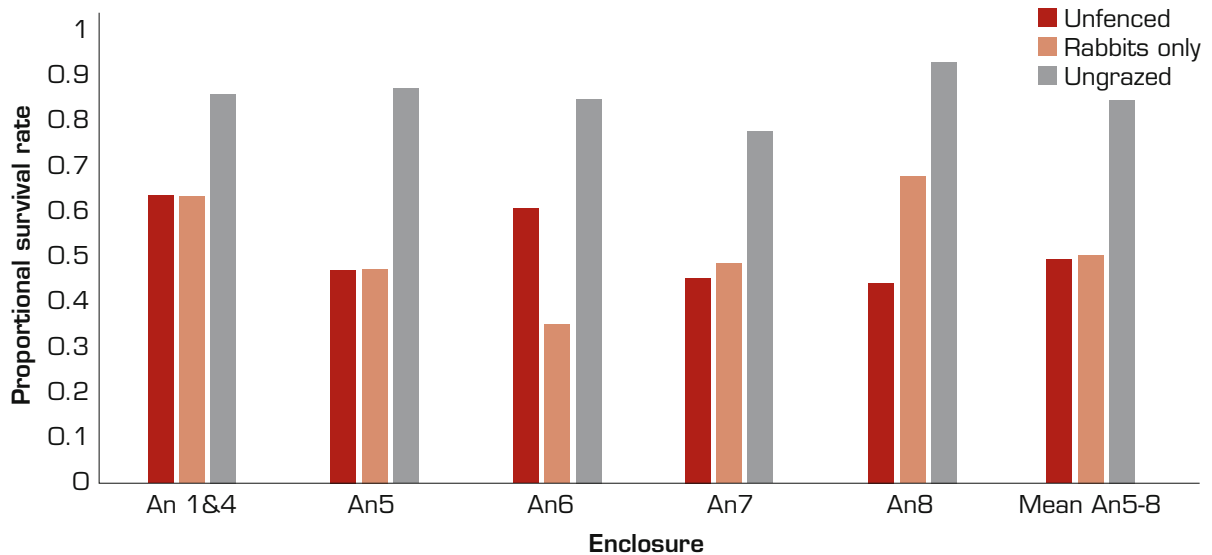
#### **Site 4 *Chenopod* shrubland and grassland enclosures, Flinders Ranges National Park**

Plant biomass and the number of perennial plants were recorded in vegetation enclosures to measure the grazing pressure of rabbits.

Control of rabbits and native herbivores enhanced biomass of short-lived chenopods and native grasses, and reduced weediness.

These data indicate that grazing by rabbits and other herbivores limits shrub recruitment and reduces the biomass of palatable species in native pastures.

**Figure 4.5 Proportional survival of mulga (*Acacia aneura*) seedlings in the six months following germination in 1997 in five sets of enclosures (An1&4, An5, An6, An7, and An8) in the Vulkathunha-Gammon Ranges National Park, South Australia. Unfenced areas are grazed by rabbits, feral goats and euros.**



**Site 5 Land condition assessment and vegetation monitoring points in Vulkathunha-Gammon Ranges National Park and Flinders Ranges National Park**

A land condition index was used to assess the land and vegetation condition based on vegetation community type, species composition and abundance, and level of grazing impact.

Overgrazing by rabbits and other herbivores reduced the general land condition, as measured by the proportions of palatable and unpalatable species in recognised vegetation associations. Photo monitoring points were also established to assess the change in vegetation over time (see Figure 4.6).

Land condition in both national parks was estimated to be poor because of historical overgrazing by livestock and the subsequent arrival of rabbits.

**Current findings**

The entire floristic integrity of arid-zone *Acacia* shrublands, survival of their dependent fauna and stability of the pastoral industries they sustain are all threatened by ongoing rabbit grazing. These studies indicate that the process of degradation is reversible for moderately palatable species. Monitoring within each of the individual monitoring programs will be ongoing.

**Further information**

Operation Bounceback, South Australian Department of Environment and Heritage<sup>18</sup>

**Figure 4.6 Photo monitoring points to assess impacts to vegetation by grazing rabbits (1992 and 2007)**



1992 (photo by Greg Mutze)



2007 (photo by Greg Mutze)

<sup>18</sup> [http://www.environment.sa.gov.au/biodiversity/bounceback\\_project.html](http://www.environment.sa.gov.au/biodiversity/bounceback_project.html) (Accessed 15 May 2008)

## Case study 7

### Monitoring predation impacts of foxes on native wildlife at Southern Ark Program, Victoria

#### Project title

Southern Ark

#### Lead agency

Victorian Government, Department of Sustainability and Environment

#### Species

Foxes (*Vulpes vulpes*)

#### Location

Far-east Gippsland, Victoria (see Figure 4.7)



Foxes pose a serious threat to native animals (photo by Sam Vine)

Figure 4.7 Location of Southern Ark area of operation



#### Monitoring

Parameters measured included changes in the distribution of small- to medium-sized native mammals under various fox-control treatments (monitoring involved a conditional case-control design).

Species monitored were:

- native animals: long-nosed potoroo (*Potorous tridactylus*), southern brown bandicoot (*Isoodon obesulus*), long-nosed bandicoot (*Perameles nasuta*), brush-tailed possum (*Trichosurus vulpecula*), and other small mammals
- foxes (*Vulpes vulpes*).

#### Impact type

Foxes are known to have a profound impact on small- to medium-sized mammals. Some of these mammals are threatened species. A reduction in fox populations following control was assumed to decrease predation rates and allow an increase in numbers and expansion of the spatial range of small mammals. The level of impact by foxes on native mammals was thought to be significant.

#### Current findings

Fox predation impacts on native wildlife are known to be significant, and small- to medium-sized mammals (35–5000 grams) (also referred to as 'critical weight range mammals') are particularly susceptible to extinction risk from fox predation.

Preliminary results indicated marginal increases in the populations of long-nosed potoroo and southern brown bandicoots at one location following fox control.

The impact of fox populations on the distribution and abundance of small mammals could not be determined fully at this early stage in the Southern Ark program. However, ongoing monitoring is expected to produce significant information regarding trends and impacts for future assessments.

#### Further information

Department of Sustainability and Environment's Southern Ark Program<sup>19</sup>

<sup>19</sup> <http://www.dse.vic.gov.au> (follow Plants & Animals link) (Accessed 15 May 2008)

## Case study 8

### Monitoring predation impacts by foxes on threatened shorebirds in New South Wales

#### Project title

NSW Fox Threat Abatement Plan — threatened shorebird program

#### Lead agency

Department and Environment and Climate Change, NSW

#### Species

Foxes (*Vulpes vulpes*)

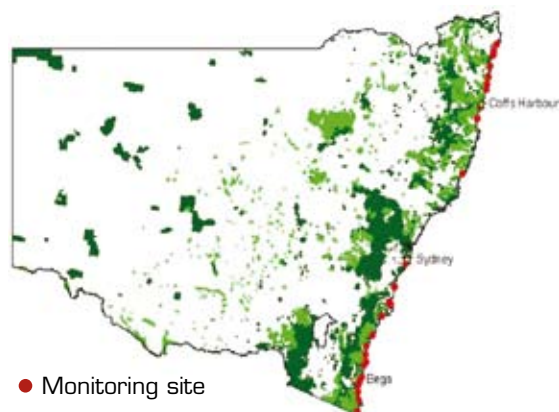
#### Location

This project monitored many of the 25 major breeding sites for threatened shorebirds (little terns, pied oystercatchers, hooded plovers and beach stone-curlews) along the NSW coastline (see Figure 4.8). Intensive broad-area (across-tenure) fox control was undertaken, wherever feasible, at sites over six breeding seasons 2001–02 to 2006–07. The allocation of sites to treatment was non-random.

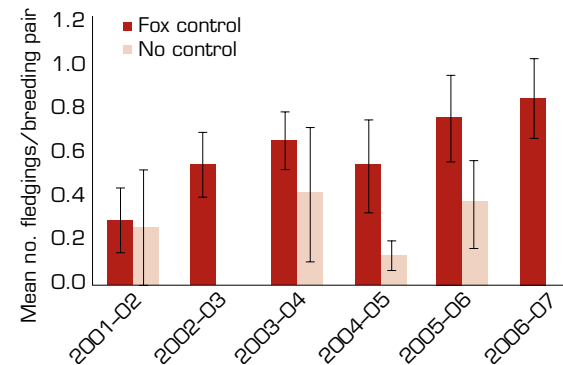
#### Monitoring and analysis

Shorebirds were observed directly at least weekly. The date of first nesting, number of adult breeding pairs, number of nests (distinguishing between clutches), number of eggs, number of chicks and the

**Figure 4.8 Monitoring sites for threatened shorebirds in NSW**



**Figure 4.9 Breeding success of little terns at sites with and without fox control**



number of young fledged were recorded throughout the season. Causes of egg and chick mortality were recorded opportunistically. Breeding success at each site was calculated as the number of young fledged divided by the number of breeding pairs. Breeding success for the period 2001–02 to 2006–07 was compared between treatments (with and without fox control) and between years.

#### Impact type

Fox predation on eggs and chicks can reduce breeding success and hence the recruitment of all four species of threatened shorebirds dramatically. Foxes have been reported to cause 100% mortality in eggs and chicks at individual sites.

#### Current findings

Breeding success of threatened shorebirds, especially little terns, was significantly greater at sites with fox control (see Figure 4.9). Nevertheless, fox predation remained a common source of mortality at all sites, suggesting there is potential to improve control programs. Measuring the effects on adult numbers is complicated by the ability of birds to move between sites. However, the number of little terns appears to be increasing across NSW. Monitoring is ongoing.

#### Further information

NSW Department of Environment and Climate Change<sup>20</sup>

<sup>20</sup> <http://www.environment.nsw.gov.au> (Accessed 15 May 2008)

## Case study 9

### Monitoring introduced predator impacts on native fauna in the Jarrah Forest bioregion, southwest Western Australia

#### Project title

Introduced and native predator interactions in the northern jarrah forest

#### Lead agency

Western Australian Department of Environment and Conservation and the Invasive Animals Cooperative Research Centre

#### Species

Foxes (*Vulpes vulpes*) and feral cats (*Felis catus*)

#### Location

The study site is the northern jarrah forest of southwest Western Australia (WA) (see Figure 4.10).

#### Monitoring

Monitoring in baited and unbaited regions encompassed:

- fox and feral cat density monitoring (through molecular techniques based on identification of individuals from hair and scats, and indexes of abundance or density from active and passive sand plots)
- trapping and radio telemetry spotlighting of chuditch, two species of varanids, the southwest carpet python and the common brush-tailed possum (to derive density estimates and habitat use)
- wire cage and Elliott and pitfall trapping techniques (to monitor prey availability)
- scat analysis (to determine whether diet reflected prey availability).

#### Impact types

Foxes are known to prey upon a suite of native species.



Foxes occupy a wide range of environments, including open woodlands (photo by Steve Lapidge)

#### Current findings and implications

This study found that:

- The impacts of foxes were mitigated by the control activities. However, potential indirect effects, including increased predation by previously subordinate predators (mesopredator release), have not yet been quantified fully.
- Conventional reporting on the extent of area subject to fox and feral cat control (ie the number of hectares baited) was insufficient to assess the effectiveness of control strategies.
- Standard techniques of monitoring passive sand plots to derive indexes of fox and feral cat activity did not reflect the long-term effectiveness of the baiting strategies.

#### Future monitoring

The effectiveness of future fox baiting in the northern jarrah forest will be assessed by quantifying fox and feral cat densities, determining if there are indirect effects from mesopredator release and monitoring the long-term biodiversity outcomes (eg a sustained increase in the abundance of native species).

#### Further information

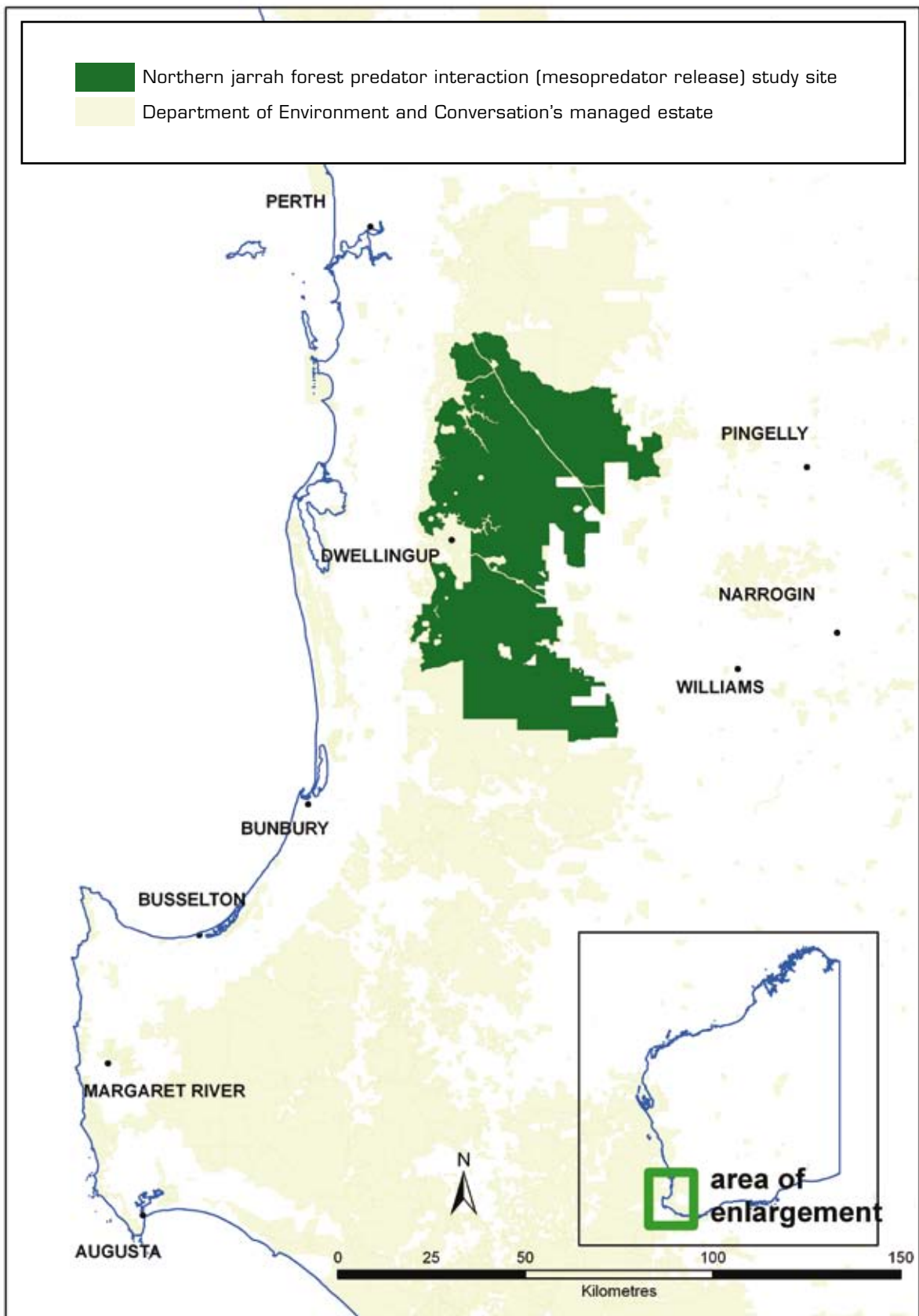
WA Department of the Environment and Conservation<sup>21</sup>

Invasive Animals Cooperative Research Centre<sup>22</sup>

<sup>21</sup> <http://www.dec.wa.gov.au> (Accessed 15 May 2008)

<sup>22</sup> <http://www.invasiveanimals.com> (Accessed 15 May 2008)

Figure 4.10 Location of the northern jarrah forest in the WA Department of Environment and Conservation's managed estate



Source: WA Department of Environment and Conservation

## Use of information about the impacts of invasive animals

Nationally significant invasive animals inhabit all areas of Australia and their impacts are significant. In total, invasive animals cause at least one billion dollars damage each year to the economy, environmental assets and society (McLeod 2004, Tracey et al 2007).

This Assessment presents some of the impacts of invasive animals through case studies from management and monitoring programs around Australia. This chapter is not intended to provide a comprehensive overview of invasive animal impacts. The case studies reported herein present a snapshot of impacts information from various areas and programs that may be used to monitor the impacts of invasive animals over time. When considered in conjunction with information on the distribution and abundance of invasive animals, these case studies provide a reference point to help define the problem(s) caused by invasive animals throughout Australia.

The case studies should be used in conjunction with existing information on the impacts of invasive animals that has been determined over many decades of research and monitoring in Australia. A wide range of scientific research is available and can be periodically reviewed to provide an overview when needed, and to track changes in the level of information and knowledge on impacts throughout Australia.

Impacts information is crucial to the management of invasive pest animals. It is required to determine management priorities, identify the level of control needed to reach goals, and evaluate previous management programs, and is fundamental for maximising the cost-effectiveness of control activities. Resources for undertaking control programs are not limitless, and there is an inherent need to allocate resources where they will achieve the most cost-effective solutions.

In most instances, measuring the precise impacts of species is particularly difficult and requires experimental procedures and sampling designs to overcome confounding factors. The case studies reported herein provide a snapshot from a small set of monitoring programs, and ongoing monitoring of impacts through case studies is required to reveal longer-term impacts of pests in Australia.

## Summary of current impacts information

The case studies selected for this Assessment reveal that invasive animals cause a wide range of ecological and economic impacts in Australia. The following list summarises current knowledge about the impacts of invasive animals from these nine case studies:

- Invasive animals cost over \$1 billion per year through economic, environmental and social damage. The main culprits are foxes, pest birds, feral cats, rabbits and feral pigs.
- Invasive animals threaten 40% of threatened biodiversity in NSW, represented by 388 species, as well as 83% of endangered animals populations and 38% of endangered ecological communities.
- All natural resource management regions contain threatened species at risk by invasive animals (eg 68% in western NSW).
- There is significant overlap between invasive animal populations and environmental assets of national importance in all state and territories of Australia.
- Feral pigs are known to cause substantial production losses to sugar cane and bananas in north Qld, costing hundreds of thousands of dollars to the industries.
- Feral pigs also prey on up to 70% of sea turtle nests in north Qld.
- Rabbits significantly affect native vegetation, particularly regeneration. They prevent recruitment of native mulga, threatened Acacias and chenopod shrublands, and contribute to poor land condition in South Australia.
- Foxes are significant predators of a wide range of native fauna in Australia, such as potoroos and bandicoots in Victoria, chuditch in WA, and threatened shorebirds such as pied oyster catchers and little terns in NSW.

## Improving monitoring and reporting of impacts

Ways to improve the monitoring and reporting of invasive animal impacts to provide more detailed assessment of pest impacts in Australia include:

- increasing investment in key research to identify the impacts of invasive animals to ensure that the impacts are addressed in broader management programs
- improving tools and techniques to monitor impacts across a range of management levels, including regional, state and territory levels
- strengthening linkages with research and monitoring programs such as Cooperative Research Centres, industry groups and national control programs (such as the National Feral Animal Control Program) to assess the social, environmental and economic impacts of invasive animals
- looking closely at a range of species and a variety of impact types; social, environmental and economic
- supporting natural resource management regional groups in monitoring and reporting activities to address key information gaps regarding impacts information for invasive animals



Cane toads (*Bufo marinus*) were introduced to control cane beetles, but have spread throughout northern Australia (photo by Liz Poon, CSIRO)

- increasing monitoring of impacts where investment programs and control activities are occurring, and ensuring that monitoring and reporting of pest impacts are prerequisites for funding of control programs.

## Lack of information on the impacts of fish, birds and amphibians

At the time of this Assessment, there were no suitable studies supplied from state and territory government agencies on the impacts of birds, fish and amphibians that could be included in this section. For future assessments, we make the following recommendations.

- To prepare a case study to identify the impacts from pest birds, use the existing 'national list of 20 pest birds in horticulture' from Tracey et al (2007) *Managing Bird Damage to Fruit and Other Horticultural Crops*. This list includes common starlings, house sparrow, European blackbird, and urban pest species such as pigeons and Indian mynas.
- There are presently 34 established alien fish species in Australia (West et al 2007). To prepare a case study to identify the impacts of pest fish, relevant state and territory fisheries departments and research organisations, such as the Invasive Animals Cooperative Research Centre, should be consulted to select suitable existing programs where the impacts of pest fish can be identified and reported.
- The impacts of cane toads in Australia are presently being investigated by numerous authorities and research specialists. To prepare a case study on cane toad impacts, relevant state and territory departments and research organisations, such as the Invasive Animals Cooperative Research Centre and The University of Sydney, should be consulted to select suitable existing programs where the impacts of cane toads can be identified and reported.