A guide to managing and restoring wetlands in Western Australia

Introduced and nuisance animals

In Chapter 3: **Managing wetlands**

Version 1

Australian Government

Department of Environment and Conservation

Our environment, our future

Introduction to the guide

Western Australia's unique and diverse wetlands are rich in ecological and cultural values and form an integral part of the natural environment of the state. *A guide to managing and restoring wetlands in Western Australia* (the guide) provides information about the nature of WA's wetlands, and practical guidance on how to manage and restore them for nature conservation.

The focus of the guide is natural 'standing' wetlands that retain conservation value. Wetlands not addressed in this guide include waterways, estuaries, tidal and artificial wetlands.

The guide consists of multiple topics within five chapters. These topics are available in PDF format free of charge from the Western Australian Department of Environment and Conservation (DEC) website at www.dec.wa.gov.au/wetlandsguide.

The guide is a DEC initiative. Topics of the guide have predominantly been prepared by the department's Wetlands Section with input from reviewers and contributors from a wide range of fields and sectors. Through the guide and other initiatives, DEC seeks to assist individuals, groups and organisations to manage the state's wetlands for nature conservation.

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For more information about the guide, including scope, purpose and target audience, please refer to the topic 'Introduction to the guide'.

DEC welcomes your feedback and suggestions on the guide. A publication feedback form is available from the DEC website at www.dec.wa.gov.au/wetlandsguide.

Contents of the guide

These topics are available in PDF format free of charge from the DEC website at www.dec.wa.gov.au/wetlandsguide.

'Introduced and nuisance animals' topic

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Disclaimer

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Case studies

Before you begin

Before embarking on management and restoration investigations and activities, you must consider and address the legal requirements, safety considerations, cultural issues and the complexity of the ecological processes which occur in wetlands to ensure that any proposed actions are legal, safe and appropriate. For more guidance, see the topic 'Introduction to the guide'.

Introduction

A wide variety of fauna (animals) may use a particular wetland or be wetland-dependent, including mammals, reptiles, fish, birds, frogs, and **aquatic invertebrates** (such as insects, snails and crayfish). Protecting, maintaining and encouraging native fauna populations at a wetland involves managing the wetland in such a way as to provide suitable habitat (an area or environment where conditions are suitable for the survival of an organism, taxon or community) for such fauna. Managing a wetland to maintain its natural state (in general terms: good water quality, healthy vegetation and unaltered hydrology) will help to maintain suitable habitat for the wetland's natural suite of fauna (Figure 1).

Figure 1. A wetland in Forrestdale which provides habitat to its natural suite of fauna due to good water quality, healthy vegetation and unaltered hydrology. Photo – C Mykytiuk/WWF.

Maintaining or improving habitat for the natural suite of native fauna often involves preventing or controlling introduced and nuisance animals. These will be predators and/or competitors of native fauna and will also degrade the habitat available for native fauna.

There are many species of introduced animals found throughout Western Australia. In fact, introduced animals may be found in almost every area of the state, with wetlands being no exception. Introduced animals may threaten **biodiversity**, degrade habitats and may have severe economic and social impacts. Some species of native fauna can seriously impact wetlands and surrounding land when in unnatural numbers, and in these circumstances may be considered 'nuisance fauna'. This topic briefly describes the introduced and nuisance species that may be present at a wetland, including **feral livestock**, the impacts these may have, and the management strategies available to address these animals.

Aquatic invertebrates: those animals without a backbone (such as insects, worms, snails, molluscs, water mites and larger crustacean such as shrimps and crayfish) that live in or on water for at least one phase in their lifecycle

Biodiversity: a contraction of the words 'biological' and 'diversity', encompassing the whole variety of life forms—the different plants, animals, fungi and microorganisms—the genes they contain, and the ecosystems they form

Feral animals: introduced animals that have escaped, or have been released, from domestication and returned, partly or wholly, to their wild state

Livestock: introduced domestic ungulate (or hoofed) animals

What are nuisance fauna?

Nuisance fauna are native animals that naturally occur at a site, but which have reached a population size that is causing harm to the environment or humans. Examples include kangaroos, Australian white ibis and midges, which can all reach unnatural numbers as a result of human alterations to the environment. Mosquitoes are also labelled nuisance insects, but they are an exception: the population of many species of mosquitoes can grow rapidly and disperse far from wetlands under the right natural conditions.

➤ For guidance on managing nuisance midges and mosquitoes, see the topic 'Nuisance midges and mosquitoes' in Chapter 3.

What are introduced animals?

The term 'introduced animals' refers to those animal species that have been intentionally or unintentionally brought into a region where they do not historically occur, usually facilitated by humans. In the Australian context, this definition includes both non-Australian animals as well as animals that are native to Australia but have been introduced from one area within the country or state to another. For example, common yabbies *(Cherax destructor albidus)* have been introduced to dams in WA from the eastern states. Some introduced animals may also be considered invasive animals, which are rapidly spreading introduced animals that out-compete native fauna for habitat.

Introduced animals are a problem because they are able to rapidly increase in numbers without natural predators or diseases to keep the population in check. Many of the introduced animals in Australia are large animals such as pigs (*Sus scrofa*) or camels (*Camelus dromedarius*). The wild ancestors of these domestic animals evolved among large predators such as the big cats, bears and wolves. In Australia, where these predators do not occur, introduced animals were able to easily establish themselves. The only natural control of most introduced animals in Australia is drought. Introduced animals numbers increase during good seasons and decline rapidly during dry times. During dry times in particular, terrestrial introduced animals seeking water are more likely to congregate around wetlands. Australia's extended evolutionary and biogeographic isolation has resulted in its native fauna being naïve and vulnerable to introduced animals, particularly predators.[1]

Since European settlement (if not before), humans have facilitated the spread of introduced animals to Australia. In a twenty-year period spanning 1860–80 more than sixty vertebrate animal species were released in Australia.[2] Many of these introductions were deliberate, in an attempt to make the European settlers feel more at home by bringing European animals to the country.[3] There were even acclimatisation societies set up solely for the purpose of spreading animals such as rabbits (*Oryctolagus cuniculus*), birds and deer for the 'benefit' of the country.[3] Animals such as rabbits and red foxes (*Vulpes vulpes*) were often released for recreational hunting while European carp (*Cyprinus carpio*) were introduced for ornamental display in garden ponds. Many other animals such as house mice (*Mus musculus*) and rats (*Rattus* spp.) were introduced into Australia accidentally on settlers' ships, while domestic animals such as cats (*Felis catus*), horses (*Equus caballus*) and camels were released from captivity into the wild.

Since the realisation that introduced animals can be harmful to Australia's environment and native fauna, introductions have mostly been accidental, although some intentional introductions (for example for hunting and fishing) still occur. Many animals kept as pets or livestock have become feral animals after straying from the properties they were kept on or after being deliberately abandoned. Animals may also be introduced to new areas by travelling unnoticed with tourists and vehicles transporting food and other products, or even by hitching a ride on debris in waterways: cane toads (*Bufo marinus*) have been reported to be 'surfing' down the Ord River by as much as 20 kilometres a night.[4]

Many of the aquatic introduced animals that occur in wetlands in WA were probably introduced as a result of aquarium and aquaculture ventures. For example, blackworm (*Lumbriculus variegatus*), commonly sold as live fish feed, and aquarium snails are commonly found in wetlands in metropolitan areas. Yabbies and brine shrimp (*Artemia* spp.) are commonly used in the aquaculture industry to feed juvenile fish in hatcheries.

Most introduced fish populations result from intentional releases, for example, of domestic aquarium fish that have been 'set free', or fish released by recreational fishers to enhance recreational fishing. Notably, eastern gambusia (*Gambusia holbrooki*) were deliberately introduced into Australian wetlands and waterways as a **biological control** agent for the control of mosquitoes in the 1920s.[5] They may now be found in most drainage channels and many wetlands along the south-western coast of WA, particularly in metropolitan areas. They were referred to as 'mosquito fish' but unfortunately they are thought to have actually benefited mosquito populations by eating the native insects which would otherwise prey on mosquito larvae. So it appears that they are quite aptly named – their genus name *Gambusia* is derived from the Cuban Spanish term *gambusino*, meaning 'useless'. Eastern gambusia also out-compete native fish for food and attack competitors including tadpoles and fish by damaging their fins.

Another notable deliberate introduction is the cane toad. Cane toads were introduced to northern Queensland from Hawaii in 1935 in an unsuccessful attempt to control cane beetles, a pest of the sugar cane industry. Having no natural enemies, the toads spread west into the Northern Territory and south into New South Wales. Cane toads have since crossed the Western Australian border in the northern part of the state. The poisonous toads are considered a threat to Western Australian native frogs and other fauna through predation, competition and lethal ingestion.

Finally, some introduced species have slipped in to Australian wetlands undetected by catching a ride on other introduced species. This is the most likely mode of entry for a European ostracod (*Physocypria* sp.), which was discovered in Lake Jolimont, Perth in 2010. It is thought that the ostracod was introduced when pet goldfish were released into the lake.[5]

Biological control: the control of an introduced plant or animal by the introduction of a natural predator or pathogen, usually bacteria, viruses or insects, or by biological products such as hormones

Amphibians: the class of animals to which frogs, toads and salamanders belong. They live on land but develop by a larval phase (tadpoles) in water.

Which introduced animals can occur at a wetland?

Table 1 provides a list of introduced animals that are known to occur at wetlands in WA. Which of these species actually occur at a wetland will depend on a number of factors, including the location of the wetland within WA and the available habitat at the wetland.

When assessing the risk of an introduced species inhabiting a particular wetland, it is important to keep in mind that factors such as climate change may alter that risk in the future. For example, some feral fish species may expand in range if wetlands and waterways become warmer or more saline in the future as a result of climate change.

Table 1 groups the introduced animals according to those that are, and are not, dependent on wetlands for their survival. 'Wetland dependent' introduced animals are those that are restricted to or dependent on wetlands for their existence. This category is dominated by aquatic species and **amphibians**. Those introduced animals that are 'not wetland dependent' are visitors to wetlands.

Table 1. Introduced animals that are known to occur at wetlands in Western Australia

Common name		Latin name	Known distribution in WA	Identification guide	Reporting
Wetland dependent					
Birds					
	Mute swan	*Cygnus olor*	Avon River, Northam	Field guide to Australian birds[7]	-
	Domestic waterfowl	*Various*	Metropolitan areas	Field guide to Australian birds[7]	-
Amphibians					
	Cane toad	*Bufo marinus*	Kununurra	DEC pamphlet Is it a cane toad?[8]	Cane Toad Hotline 1800 084 881 Kimberley residents: DEC's Kununurra Office (08) 9168 4200
Reptiles					
	Red-eared slider turtle	*Trachemys scripta elegans*	Perth. Known occurrences have been removed.	Red-eared slider: Animal pest alert No 6/20099	Department of Agriculture and Food 1800 084 881 Or DEC on 9334 0292.
Fish					
	Eastern gambusia	*Gambusia holbrooki*	South-west (widespread)	Aquatic invaders publication[10]	FISHWATCH service 1800 815 507
	One-spot live bearer	*Phalloceros caudimaculatus*	Perth metropolitan area	Field guide to the freshwater fishes of Australia[5]	FISHWATCH service 1800 815 507
	Tilapia	*Oreochromis mossambicus*	Gascoyne-Lyons river system	Aquatic invaders publication[10]	FISHWATCH service 1800 815 507
	Pearl cichlid	*Geophagus brasiliensis*	Perth metropolitan area (primarily Bennett Brook and Altone Park)	Aquatic invaders publication[10]	FISHWATCH service 1800 815 507
	Goldfish	*Carassius auratus*	South-west	Aquatic invaders publication[10]	FISHWATCH service 1800 815 507
	Swordtail	*Xiphophorus hellerii*	Irwin River, south-east of Geraldton	Aquatic invaders publication[10]	FISHWATCH service 1800 815 507
	Guppy	*Poecilia reticulata*	Northern Western Australia	Aquatic invaders publication[10]	FISHWATCH service 1800 815 507
	Redfin perch	*Perca fluviatilis*	South-west	Aquatic invaders publication[10]	FISHWATCH service 1800 815 507
	European carp	*Cyprinus carpio*	South-west	Aquatic invaders publication[10]	FISHWATCH service 1800 815 507
	Brown trout	*Salmo trutta*	South-west	Field guide to the freshwater fishes of Australia[5]	FISHWATCH service 1800 815 507
	Rainbow trout	*Oncorhynchus mykiss*	South-west	Field guide to the freshwater fishes of Australia[5]	FISHWATCH service 1800 815 507
Invertebrates					
Crayfish	Common yabbie	*Cherax destructor albidus*	South-west, Hutt and Bowes Rivers (north of Geraldton). Native to eastern states	Identifying freshwater crayfish in the south west of WA[11] Aquatic invaders publication[10]	FISHWATCH service 1800 815 507
	Smooth marron	*Cherax cainii* (previously known as *Cherax tenuimanus*)	Hutt River, Esperance, Kalgoorlie (human-aided range extensions). Native to south-west. Considered a threat in particular areas of the Margaret River only, where it is a threat to the hairy marron	A field guide to freshwater fishes, crayfishes and mussels of south-western Australia[161]	FISHWATCH service 1800 815 507
	Redclaw	*Cherax quadricarinatus*	Kimberley. Native in Northern Territory and Queensland	A field guide to freshwater fishes, crayfishes and mussels of south-western Australia[161]	FISHWATCH service 1800 815 507

Common name		Latin name	Known distribution in WA	Identification guide	Reporting
• *Snails*	Tadpole snail	*Physa acuta*	South-west	-	FISHWATCH service 1800 815 507
	Great pond snail	*Lymnaea stagnalis*	South-west coastal	-	FISHWATCH service 1800 815 507
	Brine shrimp	*Artemia franciscana* and *A. parthenogenetica*	South-west and coastal WA	-	FISHWATCH service 1800 815 507
	Blackworm	*Lumbriculus variegatus*	Metropolitan areas		FISHWATCH service 1800 815 507
	Some naidid worms	Some species within the Naididae family of worms including *Branchiura sowerbyi*	Metropolitan areas	-	FISHWATCH service 1800 815 507
	Physocypria (ostracod)	*Physocypria sp.*	Lake Jolimont	-	FISHWATCH service 1800 815 507
Not wetland dependent					
Mammals					
	Cat	*Felis catus*	All of WA	-	-
	Red fox	*Vulpes vulpes*	Southern half of state and Pilbara coast	-	-
	Domestic dog	*Canis lupus familiaris*	Pastoral areas	-	-
	Fallow deer and red deer	*Dama dama* and *Cervus elephus*	South-west	Rusa deer: Animal pest alert[12]	Department of Agriculture and Food 1800 084 881
	Camel	*Camelus dromedarius*	Inland/arid areas	-	-
	Horse	*Equus caballus*	Arid rangelands and Kimberley	-	-
	Donkey	*Equus asinus*	Inland, Pilbara and Kimberley	-	-
	Goat	*Capra hircus*	Semi-arid to arid pastoral areas (Midwest and Goldfields)	-	-
	Pig	*Sus scrofa*	South-west, Kimberley and some in Midwest and Pilbara	-	Department of Agriculture and Food 1800 084 881
	Rabbit	*Oryctolagus cuniculus*	All of WA other than Kimberley	-	If present on offshore islands report to DEC Wildcare Hotline 9474 9055
Rodents	Black rat	*Rattus rattus*	South-west and along north-west coast	-	If present on offshore islands report to DEC Wildcare Hotline 9474 9055
	Brown rat	*Rattus norvegicus*	Coastal cities of south-west	-	If present on offshore islands report to DEC Wildcare Hotline 9474 9055
	House mouse	*Mus musculus*	All of WA	-	If present on offshore islands report to DEC Wildcare Hotline 9474 9055

Detecting introduced animals

Introduced animals may be difficult to see at a wetland, but they will usually leave some signs of their presence. Signs of introduced mammals may include grazed vegetation, trampled vegetation in the form of 'runways' which they may regularly use, scats, burrows, tracks (footprints), eroded banks, diggings and signs of wallowing in mud or water. Scats and tracks are particularly useful as they may be used to identify the type of animal that is present more accurately than by using other signs (Figure 2).

- The book *Tracks, scats and other traces: A field guide to Australian mammals*[13] is useful for identifying which introduced mammals are present at a wetland.
- The Wildlife Note *Sand Pads – using tracks to monitor fauna*[14] describes how to create a sand pad for monitoring purposes.

Figure 2. (a) Tracks preserved in clay at Shirley Balla Swamp in Banjup. Photo – J Lawn/DEC. (b) Fox den at Lake Joondalup. Photo – N Hamilton/DEC.

(a)

(b)

Introduced aquatic species can be harder to detect through observation alone. At least twenty-two species of introduced fish are known to occur in Australia's fresh waters.[5] Of these, at least ten species are found in Western Australian wetlands (see Table 1).

Sophisticated techniques are also being employed to detect some animals and monitor their movements. For example, global positioning system (GPS) collars are being used to monitor foxes and feral cats in Leschenault Peninsula Conservation Park. Sniffer dogs are being used to detect cane toad fronts (Figure 3). Genetic testing of feral pig populations is being used to identify populations that have been transported to new areas by humans for hunting.

Figure 3. Nifty the cane toad detector dog works with DEC State Cane Toad Initiative technical officer Sandy Fleisher to seek out the invading fronts of cane toads in the Kimberley. Photo – M Andrews.

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

What effect do introduced and nuisance animals have on wetlands?

There are many reasons for controlling introduced animals. Certain species have devastating impacts on the Australia environment. The effects of introduced species on populations of native fauna has been recognised in the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* with the inclusion of rabbits, feral goats, foxes, feral cats, feral pigs and cane toads on the list of key **threatening processes** in Australia. From a range of serious environmental issues, the Environmental Protection Authority has assigned introduced species the highest priority ranking for policy development, management action and investment in the *State of the Environment Report: Western Australia 2007*.[15]

extra information

Socio-economic impacts of introduced animals

While this topic is focused on the management introduced animals for wetland conservation, managing introduced animals can also maintain or improve the economic, social, aesthetic or recreational values of a wetland. The impacts of introduced animals include reduced water quality, vegetation loss, soil disturbance and a loss of biodiversity, which may indirectly contribute to a wetland becoming less attractive for tourism and recreation, and in turn lead to a reduction in economic assets.

Introduced animals using, or living in, a wetland can also impact on surrounding land uses. Camels can seriously damage pastoral and community infrastructure. The great pond snail (*Lymnaea stagnalis*) is a host for liver fluke (*Fasciola* spp.), which is an internal parasite that affects humans and many herbivorous mammals including sheep and cattle. The disease caused by liver fluke, fasciolosis, occurs in humans in some parts of the world. It can also cause severe agricultural production losses and death in livestock. These are but a few of the wide-ranging effects of introduced animals on land uses surrounding wetlands.

Introduced animals may impact a wetland primarily in two ways: by affecting other animals within the wetland, and by affecting the wetland environment itself.

Herbivores: animals that chiefly eat plants

Omnivorous: feeding on both plants and animals

Effects on native fauna

Introduced predators can have devastating effects on the fauna found at a wetland. Introduced animals may directly affect native fauna in a number of ways, the most obvious of these being predation of native fauna. Other impacts include aggressive and competitive behaviour towards native fauna, the spread of diseases, causing behavioural changes in native animals, and hybridising with native fauna. Each of these effects is discussed below in more detail.

Predation

Feral cats and foxes prey on native birds, mammals and reptiles. Feral cats alone have been implicated in the elimination of twenty-three native animal species in Australia.[16] Foxes have also been responsible for the disappearance of many native fauna species and are affecting the survival of many other species of mammals, reptiles and birds.[1,17,18,19,20] In Perth's urban wetlands, foxes have been implicated in the lack of and reduced recruitment of oblong turtles (*Chelodina colliei*) (also known as long-necked or snake-necked turtles) in some urban wetlands. They are known to dig up and eat turtle eggs. Feral cats and foxes are attracted to wetlands by the large numbers of fauna in these areas, particularly when waterbirds are breeding.

The presence of introduced **herbivores** at a wetland may indirectly affect its native fauna. For example, large populations of rabbits and rodents may attract cats and foxes to the wetland, putting native species at risk. Rabbits and rodents are a major component of the diet for both feral cats and foxes.[21,22,23,24]

Pigs are **omnivorous** and consume a wide range of flora as well as fauna.[25] Feral pigs are active predators of native birds, reptiles (including their eggs), frogs and invertebrates within the soil such as earthworms. Other introduced predators include rodents which may prey on eggs, small reptiles and even juvenile birds.[26,27] Eastern gambusia eat insects that prey on mosquito larvae, and so change the composition of the aquatic invertebrate community within a wetland. Eastern gambusia also eat the eggs of native fish. Carp rarely eat other adult fish but do eat fish eggs or larvae. In a laboratory study yabbies were found to prey on and show strongly aggressive behaviour towards tortoise hatchlings.[28] These results suggest yabbies could be harmful to juvenile tortoises and have the potential to pose a serious threat to some tortoise populations and species.

Juvenile and adult cane toads feed on a broad variety of small prey, predominantly ground-dwelling invertebrates. The bulk of the diet is usually ants, beetles and termites, although they can eat anything that fits in their mouth, including a wide variety of insects, frogs, small reptiles, mammals and birds.[29] Cane toads are thought to consume approximately 200 food items per night, far more prey than most native frogs ingest in the same period.

Competition

Introduced animals may compete with native fauna for food, shelter or breeding habitat (Figure 4). They are also often more aggressive and so displace native fauna. Yabbies (*Cherax destructor albidus*) are known to compete with the native marron (*Cherax cainii*) and gilgies (*Cherax quinquecarinatus* and *C. crassimanus*) for shelter in clay substrates. Access to these clay substrates is important for marron as it provides protection from predators and cannibalism.[30,31] Yabbies have been shown to directly compete with *C. cainii* for food resources and are also expected to outcompete native crayfish when present.

Figure 4. Introduced ducks chasing a native pacific black duck (*Anas superciliosa*), affecting the native duck's choice of habitat and access to potential mates. Photo – A Nowicki/DEC.

Some native fauna, such as bilbies (*Macrotis lagotis*), require a constant supply of carbohydrate-rich seeds and roots.[32] If these are all consumed by introduced herbivores then the native fauna are at risk. Feral pigs eat fungal fruit-bodies, which are also eaten by several small mammal species[33,34], including the Gilbert's potoroo (*Potorous gilbertii*) and southern brown bandicoot (*Isoodon obesulus*). In the eastern states, such competition is a particular threat to the endangered long-footed potoroo (*Potorous longipes*), the diet of which is more than 80 per cent fungal fruit-bodies.[34] Introduced fish often compete with native fish. For example, carp compete strongly with other fish and aquatic invertebrates for food and habitat, affecting the diversity and abundance of these fauna in the water.[30]

Competition among animals may involve very aggressive behaviour, resulting in injury or even death. For example, eastern gambusia and tilapia are very aggressive fish and will nip the fins and eyes of native fish. Even if they do not kill the victim, the injuries sustained by native fish may eventually prove fatal due to their weakened state and susceptibility to infection which may affect their ability to find food or avoid predators.

Cane toads are unique as they have a lethal defence mechanism. All stages of the cane toad's life cycle—eggs, tadpoles, toadlets and adult toads—are poisonous.[29] Cane toads have venom-secreting poison glands (known as parotoid glands) or swellings on each shoulder from which poison is released when the toads are threatened.[29] Native predators are not used to frogs being poisonous as no species of native frog in WA has this defence mechanism. Because of this naivety among native fauna, cane toads could devastate the native fauna populations of a wetland.

The red-eared slider (*Trachemys scripta elegans*) is one of the top 100 'World's Worst' invaders as determined by the International Union for the Conservation of Nature and is considered a major threat to biodiversity (Figure 5). It is native to the United States and Central America and is a popular turtle in the pet industry in some countries. Red-eared sliders were brought to Australia in the 1960s and 1970s.[35] Many were released into the wild after owners discovered their aggressive nature and tendency to bite and they are now an invasive pest in several states. In Australia, owning red-eared sliders is banned because of the threat the turtle poses to wildlife. In Australia, they compete with native turtles for food, nesting areas and basking sites; and by eating hatchlings and carrying diseases that can infect native turtles, while in England they have been reported to damage waterbird nests when using them as basking sites.[9] Even at low numbers they have the potential to create large populations; females can live for forty years, laying up to seventy eggs annually.[36] It is likely that red-eared sliders are still being kept illegally as individuals have been found and removed in the Perth region, including at Tomato Lake and Hyde Park, on three occasions in recent times.[37]

Figure 5. The red-eared slider turtle (*Trachemys scripta elegans*) is a serious threat to native fauna in Western Australian wetlands. Photo – P Lambert/DEC.

Disease

Introduced animals may carry diseases, parasites or pathogens to which native fauna are very susceptible. The following examples are just some of the many diseases that may be transmitted by introduced animals.

Cats are known hosts of the parasite *Toxoplasma gondii* which is responsible for the disease toxoplasmosis.[38] Symptoms of toxoplasmosis have been found in more than twenty species of mammals and the disease has been speculated to be a cause of decline of carnivorous marsupials.[39] Toxoplasmosis can also be transmitted to humans. Symptoms include lethargy, poor coordination, blindness and possible death.[40]

Feral cats and foxes are carriers of *Spirometra erinacei*, which causes muscular haemorrhage, damage to soft tissue and may cause death in native fauna.[41] Feral cats are also carriers for the disease sarcosporidiosis which may be transferred to native fauna, livestock and humans.[18] Pigs are potential carriers for many diseases that are transferable to livestock, native fauna and humans, including foot and mouth disease and tuberculosis[25] and hydatids, which has spread to the local western grey kangaroo (*Macropus fuliginosus*) population at Glen Eagles Forest.

Fish that are translocated from other bioregions, states or countries are potentially carriers of diseases and parasites. Some of the more serious fish diseases include epizootic ulcerative syndrome (red spot disease), irodovirus, goldfish ulcer disease, epizootic haematopoietic necrosis (redfin virus or EHNV), viral encephalopathy and retinopathy (nodavirus or VER), and infectious hypodermal and haematopoietic necrosis (in crustaceans). EHNV is a type of iridovirus which has the potential to affect fish, reptiles and amphibians. Fish such as redfin perch, rainbow trout, silver perch, and eastern gambusia are known to be susceptible to EHNV, and it is thought that most native Australian fish are also susceptible. Signs of disease or significant numbers of dead fish in wetlands should be reported to the Department of Fisheries WA, by calling FISHWATCH on 1800 815 507.

Yabbies are also known to carry many diseases and parasites, the most serious and widespread of which is the parasite *Thelohania parastoci*, which causes disease in native crayfish.[40,41,42] Infection by this parasite causes destruction of muscle tissue and reduced movement. This can lead to mortality by reducing the ability of infected crayfish to compete with healthy crayfish and increasing their risk of predation.

Feral animals can also spread disease to domesticated animals. For example, feral horses can carry exotic diseases such as equine influenza and African horse sickness, which are serious threats to domestic horses. They can also carry tick fever, which can infect domestic horses and cattle.[42] The management of feral populations can be of benefit to both conservation and agriculture.

Hybrids: the results of interbreeding between two animals or plants of different species

Grazing: feeding on grasses and other low-growing herbaceous vegetation

Browsing: feeding on leaves, twigs or bark from non-herbaceous (woody) plants, such as trees and shrubs

Behavioural changes

Just the presence of some introduced animals, particularly predators, at a wetland may influence the well-being of native fauna by changing their behaviour. Activities such as foraging for food or seeking mates generally make an animal more prone to predation or aggression from other species. If native fauna can detect (for example, through smell) their predators such as feral cats or foxes, they might change where and how often they eat, what time of the day they are active, or with whom they choose to mate.[62,63,64,65] Such changes to an animal's behaviour can mean that it doesn't get the optimal food or habitat and that it uses too much energy which, ultimately, can affect its health, reproductive success and chances of survival.

Hybridisation

Some introduced animals are able to interbreed with native animals to produce **hybrids**. Large-scale hybridisation reduces the genetic integrity of the species being hybridised and may eventually result in the pure form of the species becoming extinct.

This may one day be the fate of dingoes (*Canis lupus dingo*), which are relatively rare in their pure form, as most have hybridised with domestic dogs. Predation and hybridisation by wild dogs has been listed as a key threatening process in New South Wales.[43] Domestic waterfowl may also breed with native waterfowl. For example, introduced mallard ducks (*Anas platyrhynchos*) can interbreed with native pacific black ducks to produce fertile hybrid offspring, which can go on to produce more hybrids.[44]

Effects on the environment

Changes to the environment will often indirectly affect the fauna that live at, or visit, a wetland by changing the habitat available or limiting food resources.

Vegetation loss

Many introduced animals are herbivores that remove plants, including below-ground plant parts. Herbivores remove the leaves from plants and sometimes uproot the whole plant. Continual **grazing** or **browsing** can reduce native plant diversity, structural complexity of vegetation and degrade wetland habitats. Camels, for example, are voracious herbivores; they can browse 80 per cent of arid land plant species (Figure 6).

Figure 6. Camels at a wetland in the Rudall River area of the Pilbara. Camels have serious detrimental effects to wetlands in arid to semi-arid areas of Western Australia. Photo – B Ward/DEC.

As introduced animals often prefer to eat fresh growth, continual grazing and browsing can limit the growth and spread of new plants. Introduced animals may also trample plants in and around wetlands causing damage to, or removal of, the plants. In droughts, large herds of over one hundred camels may congregate on available water. This causes overgrazing, trampling, pugging and fouling of wetlands. Feral livestock may also strip bark off trees or rub up against trees, causing tree death by ringbarking. This is true of male feral deer, which can severely damage trees when rutting. In the eastern states, deer have had major impacts on endangered freshwater wetland communities.

The removal of plants by heavy grazing or browsing can mean that there is less food, shelter and reproductive habitat available for native animals. The loss of native vegetation may also allow weeds to establish, reduce biodiversity, and may lead to soil **erosion** and water quality problems through increased run-off.

Weed dispersal

Introduced animals are often highly mobile and may bring weed **propagules** to a wetland. Disturbance of habitats caused by introduced animals may also facilitate the invasion and spread of weeds.[34] The introduction and spread of weeds at a wetland can affect the composition of plant communities, thereby reducing the available habitat for native fauna. Weeds can also increase the threat of fire at a wetland by increasing the fuel load.

➤ For additional detail on the impacts and management of weeds, see the topic 'Wetland weeds' in Chapter 3.

Spread of pathogens and viruses

As well as weeds, introduced animals may spread pathogens such as *Phytophthora cinnamomi*, a microscopic soil-borne organism belonging to the water moulds. This introduced organism is responsible for the decline and death of native vegetation, known as Phytophthora dieback. For example, there is evidence that feral pigs can carry *P. cinnamomi* on their hooves[45], and that the spread of the pathogen can be associated with soil disturbance and reduction of litter cover by pigs.[46] Furthermore, chewing and other damage to tree trunks may facilitate infection of vegetation by the fungus and other diseases.[34] The typically omnivorous diet of pigs also leads to the passage of *P. cinnamomi* infected plant material through their digestive system, providing an additional means of spreading the pathogen among native vegetation.[47]

➤ For additional detail, see the topic 'Phytophthora dieback' in Chapter 3.

It is thought that introduced aphids are the source of an introduced virus, the bean yellow mosaic virus, which is decimating an aquatic herb species in the Swan River in Perth. Water ribbon (*Triglochin* sp.) was once common along the river foreshore and played an important ecological role by filtering nitrates and phosphates from the river. It is now restricted to a few isolated pockets near Guildford.[48]

Soil disturbance

Introduced animals may cause land degradation by disturbing the soil at a wetland. Soil compaction or erosion is often a consequence of overgrazing by introduced animals or direct damage from **pugging**, rooting, digging, burrowing or wallowing. These actions can have major impacts on flora and leaf litter, particularly after rain when the ground is softer.[34]

Soil disturbing activities are particularly a problem at wetlands. Feral pigs wallow in mud during hot weather, causing significant damage to wetlands. Such actions can create **turbid** conditions and/or **sedimentation** of the water.[34] Muddy water with a high **turbidity** allows less light to penetrate the water to plants and algae, which causes

Erosion: the gradual wearing away and movement of land surface materials (especially rocks, sediments, and soils) by the action of water, wind, or a glacier

Propagule: any part of a plant from which a new plant can grow, including seeds, bulbs and rootstocks

Pugging: depressions, hoof prints or 'pug' marks made in wet soil by trampling animals

Turbid: the cloudy appearance of water due to suspended material

Sedimentation: the process by which soil particles (sand, clay, silt, pebbles and organic materials) suspended in water are deposited or settle to the bottom of a water column.

Turbidity: the extent to which light is scattered and reflected by particles suspended or dissolved in the water column.

reduced plant growth or plant death. As sediments begin to settle, they smother animals living on the bottom by clogging their gills and causing problems for filter-feeders; coat organic deposits and algae upon which aquatic animals depend for food and cover; and fill in aquatic habitats.[49,50]

Eutrophication: the nutrient enrichment of a water body, which can trigger prolific growth of plant material (phytoplankton, macrophytes or both). May occur naturally over geologic time or may be human-induced

Water quality decline

As mentioned above, introduced animals can affect the water quality of a wetland by impacting on wetland soils and vegetation. In addition to this, introduced animals affect the water quality of a wetland by defecating and urinating in or near the wetland.[34] Even animals that mostly live terrestrially and only visit wetlands, such as cats, foxes or pigs, will congregate around water points and are likely to foul the water with their wastes. Such activities may have a number of flow-on effects such as changed nutrient levels, leading to **eutrophication** of the wetland and algal blooms.

Eutrophication of a water body may lead to nuisance midge and mosquito problems. The management of these nuisance fauna may further affect the water quality of a wetland. For example, some poisons used at wetlands as a method of controlling nuisance mosquitoes and midges have the potential to pollute to the water and cause harm to other fauna.

➤ For additional detail on management of mosquitoes and midges see topic 'Nuisance midges and mosquitoes' in Chapter 3.

The presence of introduced animals at a wetland may lead to soil disturbance that may lead to an increase in the turbidity of the water in a wetland. Carp and goldfish vigorously stir up sediment while feeding, which can change the suitability of the wetland for other species as well as potentially releasing phosphorus locked in the sediments.[51]

➤ For additional detail on the impacts of poor water quality and its management see the topic 'Water quality' in Chapter 3.

Goldfish (*Carassius auratus*) have also been found to stimulate the growth of some toxic cyanobacteria species that pass through their gut, such as *Microcystis aeruginosa*.[52] Under the right conditions species such as *Microcystis* can form blooms which can cause significant ecological impacts in wetlands. An increase in cyanobacteria can in turn provide goldfish with an abundant food source, creating the potential for an ongoing cycle of ecological impacts. Researchers found this to be an issue of significant concern for the Vasse River in the south-west of WA.[53]

Who is repsonsible for managing introduced and nuisance animals?

At the private property level, landowners and/or managers are responsible for introduced animal damage control (that is, damage to agricultural products such as crops, and to infrastructure such as fences and water points). If declared pests of agriculture are present on private property, landowners are compelled to control the species under the *Agriculture and Related Resources Protection Act 1976*. There are some exceptions to this, which relate to the control of native fauna species. Native fauna species can only be controlled if DEC approves control via a licence, an open season or declares a species' status to be 'unprotected' (Table 2 provides more information about this).

While individual landowners have this responsibility, animals generally do not restrict their movements to property boundaries and so effective management of introduced animals usually involves cooperation between landholders, community groups, councils and regional management authorities.

Landowner assistance

Private landholders can receive assistance with introduced animal management activities from a range of government and non-government programs.

For example, DEC's *Healthy Wetland Habitats* program: eligible landowners on the Swan Coastal Plain can receive funding to manage introduced species. For more information telephone the *Healthy Wetland Habitats* program coordinator on (08) 9334 0333.

➤ For more information on various programs that provide landowners with assistance, see the topic 'Funding, training and resources' in Chapter 1.

Community initiatives

The community is at the forefront of a range of on-ground management initiatives. The 'Red Card for the Red Fox' program is one such initiative that was started in 2003 by two community landcare groups working together, but has steadily developed into a statewide program and attracted funding and technical support from regional natural resource management organisations and government. In 2009, 5,000 foxes, 2,500 rabbits and 230 feral cats were shot as part of this program.[54]

Another successful community-initiated program, the Lake Muir/Denbarker Community Feral Pig Eradication Group, is the subject of a case study entitled 'Fighting feral pigs on the South Coast' presented later in this topic.

State government programs

Various Western Australian government agencies coordinate and participate in on-ground control, regulation, research and monitoring of introduced species.

The WA Department of Agriculture and Food (DAFWA) coordinates the management, control and prevention of introduced species; the prohibition and regulation of the introduction, spread and keeping of certain plants and animals for the protection of agriculture and related resources generally. DAFWA coordinates surveillance and research into vertebrate animal pests and regulates the introduction and spread of introduced species via the *Biosecurity and Agriculture Management Act 2007*. It operates the Pest and Diseases Information Service, which provides information on pests and diseases that affect community and industry well-being in WA, and provides advice on options for control of introduced species. It can provide information on when a licence is required, procedures to follow to obtain licences and the conditions that need to be adhered to when undertaking control activities.

The Department of Fisheries is responsible for controlling the introduction and spread of introduced fish and crayfish, and regulating fishing and fish stocking of state water bodies. It maintains the noxious fish species list and operates the FISHWATCH Service, which is responsible for receiving reports of sightings of freshwater pest species, including introduced freshwater crustaceans. It should be used to notify the Department of Fisheries of mass fill kills as well as reporting illegal fishing activity.

DEC protects and regulates interactions with Western Australian fauna, including fauna surveys and control of nuisance populations of native fauna under the *Wildlife Conservation Act 1950*. DEC manages the *Western Shield* program, which is the world's largest introduced predator control and biodiversity conservation program. *Western Shield* involves 1080 baiting of about 3.5 million hectares in the south-west of WA, allowing native fauna to be reintroduced to their former range. So far, the program has been successful in bringing at least thirteen native species back from the brink of extinction.[15] The State Cane Toad Initiative is also run by the department.

There is limited strategic monitoring of invasive species by state government departments across the state's large geographic area. DAFWA has recently published a monitoring framework for ecologically significant invasive species for natural resource management groups in WA.[55]

Although the control of introduced animals is not currently coordinated nationally, a number of national programs are in place.[56] Two of the national organisations dealing with pest animal control are the Vertebrate Pests Committee and the National Introduced Animal Control Program. The Invasive Animals Cooperative Research Centre was also formed in 2005 and combines the collective knowledge of forty-three research, industry, environmental, commercial and government organisations.

What are the legal requirements for managing introduced and nuisance animals?

Ethical treatment of animals

All introduced and nuisance animal control programs in WA must consider the ethical treatment of animals. Their treatment is governed by the *Animal Welfare Act 2002*, which prohibits cruelty to, and other inhumane or improper treatment of animals. Control and euthanasia are to be conducted humanely and legally, be target specific, and cause no suffering to target or non-target fauna. In order to achieve this, the people undertaking these activities must be competent and, where necessary, licensed to do so.

Industry best practice standards

Adhering to codes of conduct and standard operating procedures ensures that activities are humane, legal and in accordance with best practice standards.

Codes of conduct and standard operating procedures

Code of practice for the capture and marketing of feral animals in Western Australia, Department of Local Government and Regional Development (2003).[57]

A large number of codes of conduct and standard operating procedures for the humane capture, handling or destruction of introduced animals in Australia are available from Department of Sustainability, Environment, Water, Population and Communities website (www.environment.gov.au).[58]

DEC's standard operating procedures for monitoring (which includes trapping that may be extended to control operations) are available from the DEC website (www.dec.wa.gov.au).[59]

Permits, licences and laws relevant to animal control

Most introduced and nuisance animal management activities require authorisation, generally in the form of a permit, licence or exemption. Table 2 below provides a guide to the most common permits and licences. Table 3 lists other relevant laws which must be observed when undertaking animal management activities.

Table 2. A guide to some of the permits and licences required for a range of introduced and nuisance animal management activities

Note 1: in addition to the below, individuals must be authorised to enter any property at which activities are to be conducted.

Note 2: this information may change over time. It is important to keep up to date with legal requirements associated with introduced animal management activities.

Activity	Permit/license/approval required	Regulating authority	Legislation	For more information
Native fauna licence surveys (including macroinvertebrates)	A licence is required under Regulation 17, 'Licence to take fauna for scientific purposes'. It is referred to as a 'Regulation 17' licence.	Department of Environment and Conservation	*Wildlife Conservation Act 1950*	Application for licence to take fauna for scientific purposes[60]
	A 'Scientific exemption' permit is required under Regulation 178 to take some freshwater species including fish and crayfish for scientific purposes.	Department of Fisheries	*Fish Resources Management Act 1994*; Fish Resources Management Regulations 1995	Contact the Department of Fisheries
Culling of native species for conservation purposes (e.g. kangaroos, Australian white ibis)	A licence is required under Regulation 15, 'Licence to take fauna for educational or public purposes'. It is referred to as a 'Regulation 15' licence. This licence is not required when a species is unprotected by virtue of an open season or restricted open season notice.	Department of Environment and Conservation	*Wildlife Conservation Act 1950*; Wildlife Conservation Regulations 1970	Application for a Regulation 15 licence – to take fauna for education or public purposes (fauna relocations and/or education)[60]
Use of traps for land-based non-native species	A permit is required to use any type of trap or snare in some metropolitan and outer metropolitan areas. The permit is requested via an 'Application to Trap Declared Animals'. Individual local government authorities may also have requirements.	Department of Agriculture and Food	*Agriculture and Related Resources Act 1976*; Agriculture and Related Resources Protection (Traps) Regulations 1982	Contact the Department of Agriculture and Food
Use of bird traps	A licence is required under Regulation 11, 'Licence to take avian fauna for sale'. It is referred to as a 'Regulation 11' licence.	Department of Environment and Conservation	*Wildlife Conservation Act 1950*; Wildlife Conservation Regulations 1970	Refer to the Fauna licensing page of DEC's website[60]
Use of firearm	A licence from the Western Australian Police is required to possess, carry and lawfully use a firearm.	Western Australia Police	*Firearms Act 1973*	www.police.wa.gov.au[61]

Activity	Permit/license/approval required	Regulating authority	Legislation	For more information
Use of pesticides (including 1080, fumigants and rotenone)	All instructions on the label of the pesticide container regarding the safe use, storage and disposal of registered products must be followed.	Department of Health	*Health Act 1911*; Health (Pesticides) Regulations 1956	
	A 'Minor Use' or 'Emergency' Permit is required to use a pesticide on a species not identified on the label or in situations not stated on the label.	Australian Pesticides and Veterinary Medicines Authority	*Agricultural and Veterinary Chemicals Code Act 1994*	www.apvma.gov.au/publications /fact_sheets/docs/permits.pdf www.apvma.gov.au/permits
	1080: Trained landholders and land managers can purchase bait products containing 1080 once baiting approval has been obtained through a formal process from the. Only trained and licensed personnel can prepare and mix baits.	Department of Agriculture and Food	*Agriculture and Related Resources Act 1976*	Landholder information for the safe use and management of 1080[62]
Removal of introduced freshwater species of fish and crustaceans from wetlands	An exemption, approval or authority for the purpose of 'fish stock depletion or enhancement' is required under Section 7 of the Act. Alternatively, the department may deem that a recreational fishing licence is required. It is a contravention of the Act to be in possession of most fishing equipment at wetlands in the state without an exemption from the CEO of the Department of Fisheries. Section 104 of the Act specifies that noxious fish listed in Schedule 5 of the Regulations must not be kept in a person's possession or be allowed to remain alive.	Department of Fisheries	*Fish Resources Management Act 1994*; Fish Resources Management Regulations 1995	Contact the Department of Fisheries Recreational fishing: refer to the most current recreational fishing guide on freshwater angling for the bioregion from www.fish.wa.gov.au
Relocation, introduction or reintroduction of freshwater species of fish and crayfish	An exemption is required under Section 7 of the Act for scientific research, fish stock depletion or enhancement; or the collection, keeping, breeding, hatching or culturing of rare and endangered fish. Written authority is required under regulation 176 of the Regulations to bring into the state, or a particular area of the state (i.e. translocate from another area or bioregion), a live fish of a species not endemic to the state or area of the state.	Department of Fisheries	*Fish Resources Management Act 1994*; Fish Resources Management Regulations 1995	
	A 'Regulation 15' licence is needed to move native species.	Department of Environment and Conservation	*Wildlife Conservation Act 1950*	
Shockwaves	A valid Shotfiring permit is required to employ shockwaves. Only fully trained, accredited and licensed operators can carry out this procedure. It is the responsibility of the shotfirer to ensure that all operations undertaken are compliant.	Department of Minerals and Petroleum Resources	*Explosives and Dangerous Goods Act 1961*; Western Australian Explosives Regulations 1963	Department of Minerals and Petroleum Resources

Table 3. General requirements when undertaking animal management activities

Activity	Requirement	Regulating authority	Legislation
All animal management activities	Humane and proper treatment of animals.	Department of Local Government and Regional Development	*Animal Welfare Act 2002*
All activities being undertaken by an employee	Requires employers to identify potential hazards and to develop strategies to minimise the risk of injury or disease. Requires employees to ensure their own safety by following instructions and correctly using any safety equipment provided.	Department of Consumer and Employment Protection, WorkSafe	*Occupational Safety and Health Act 1984*; Occupational Safety and Health Regulations 1996
Activities which, if implemented, are likely to have a significant effect on the environment	Referral of thse proposals to the Environmental Protection Authority.	Environmental Protection Authority	*Environmental Protection Act 1986*
Noise due to shooting	Noise associated with the use of firearms.	Department of Environment and Conservation	Environmental Protection (Noise) Regulations 1997
Removal of non-native species from DEC-managed land	Authority from DEC is required under Regulation 18.	Department of Environment and Conservation	Conservation and Land Management Regulations 2002

How to manage introduced and nuisance animals

There are two main strategies for the management of introduced animals in wetlands:

1. prevention, typically using barriers such as fences, screens and nets to prevent access to a wetland
2. control, using one or more methods, to either reduce the population size or eradicate the population.

As with any threat to a wetland, the best management strategy is to avoid it in the first place. However, if introduced animals become established at a wetland, the best thing to do is to remove those animals. Complete removal of a population of a particular introduced animal may not always be feasible. In this case, population control may still be an option to reduce the introduced animal population to low numbers. Both activities need to be complemented with prevention methods to prevent new or additional individuals from reaching the wetland.

Prevention strategies are particularly relevant for introduced animals for which there are currently no approved control methods available. Introduced aquatic snails, brine shrimp, blackworm and naidid worms cannot be removed from a wetland once established (C Francis 2009, pers. comm.). However, the impact of these species on wetlands is generally limited and so removal of these introduced animals may not be the highest priority.

The decision to undertake management at a wetland should only be made after a management planning process has been completed and a management plan prepared, however basic it may be. Undertaking a management planning process will involve examining all of the threats at a site and assessing which of these is a priority for management. For example, if altered hydrology and introduced animals such as cats are issues at a wetland, it may be determined that managing altered hydrology is a high priority issue and until this is addressed no action will be taken to manage the introduced animals.

➤ For guidance on wetland management planning, see the topic 'Wetland management planning' in Chapter 1.

Any management of introduced animals at a wetland, be it prevention or control, requires an integrated approach. Animals generally do not restrict their movements to property boundaries and so effective management of introduced animals will often involve cooperation between landholders, community groups, councils and regional management authorities.

Considerations when selecting management techniques

When choosing a method to control a population of introduced animals, some key requirements should be considered. It must be:

- Legal: relevant legal approvals, licences and permits should be obtained and conditions of the licence or approvals understood before any management action is undertaken.
- Informed: make sure that the target species is not, in fact, a similar-looking native species.
- Without, or at an acceptable level, of adverse side effects: the environment and native animals should not be adversely affected.
- Feasible in the long term: that is, it will actually stabilise or reduce numbers over long periods. It is common for people to discover that the required frequency and duration of the control activity (for example, baiting or trapping) is often much greater than anticipated.
- Part of the bigger picture: working to control a species at a site is often futile if they are not being controlled in adjacent areas. Coordinated action at a broad scale is usually most effective.
- Undertaken with an awareness of consequences: it is common for the removal of one introduced species to cause another introduced species to increase in numbers (for example, numbers of cats often increase when fox numbers are controlled). A well-planned strategy will address this.
- Cost-effective: management should be economical in terms of the values or benefits gained in return for the money spent.
- Humane: the animals themselves should not suffer and violence should be avoided.
- Internationally acceptable: that is, the management method adopted should not affect the same or similar species in other countries. This is especially true of any immunocontraceptive (sterilisation-causing) organism that is spread by a carrier.

Quick guide to the prevention and control options by animal

Table 4. Summary of key management options by animal

Note 1: preventative actions such as wetland restoration, community education, awareness and legal avenues are applicable to all introduced animals and as such are not addressed in the table.

Note 2: as there are no approved/effective control measures available for introduced aquatic snails, brine shrimp, blackworm and naidid worms, these are not addressed in the table.

	Prevention	Control						
Animal	**Barriers (page 24)**	**Trapping (page 26)**	**Shooting (page 36)**	**Poisoning (page 37)**	**Fumigating (page 40)**	**Shockwaves, electrofishing (page 41)**	**Manipulating habitat and food (page 42)**	**Removing manually (page 44)**
Domestic waterfowl		•	•					
Australian white ibis			•				•	
Cane toad		•						•
Red-eared slider turtle		•	•					•
Introduced fish	•	•		•		•	•	•
Introduced crayfish		•					•	
Cat	•	•	•	•				
Red fox	•	•	•	•	•		•	
Domestic dog	•	•	•	•				
Kangaroo	•		•					
Deer	•		•					
Camel	•	•	•					
Horse	•	•	•					
Donkey	•	•	•					
Goat	•	•	•					
Pig	•	•	•	•				
Rabbit	•	•	•	•	•		•	
Rodents		•		•				

Prevention

Prevention is the most important and effective strategy in managing introduced animals, as controlling introduced species is often difficult, if at all possible. Prevention of the establishment of introduced animals at a wetland includes:

- maintaining or restoring wetlands
- community awareness and education
- legislation
- physical barriers.

These preventative measures should be combined with surveillance activities. Depending on the risk of introduced species and the threats they pose to the wetland, the level of surveillance may range from casual observation to comprehensive surveys.

➤ For guidance on wetland monitoring, see the topic ‘Wetland monitoring’ in Chapter 4.

Maintaining and restoring wetlands

The conditions within modified and degraded wetlands can favour the establishment and domination of some introduced species. For example, some degraded wetland habitats can be more favourable for introduced fish such as the eastern gambusia (*Gambusia holbrooki)* than native species.[63] Maintaining or restoring the natural ecosystem may help prevent such species from establishing or out-competing the native species.

Community awareness and education

Many of Australia's introduced animals were introduced by humans, either directly or indirectly through domestic or livestock 'escapes'. Community awareness and education provide valuable tools for the prevention of further introductions. Education and awareness-raising programs may be aimed at preventing new introductions or encouraging community members to monitor for new invasions. The public may be informed not to release pets (particularly aquarium fish or rabbits) and to ensure pet cats and dogs are sterilised, kept on a lead at all times while outdoors and don't roam freely through wetlands. The public should also be aware of the impacts of deliberately releasing animals such as pigs or fish for hunting and recreational purposes.

There are many tools available to raise the level of community awareness and education. The print, broadcast and internet media can be powerful allies in educating the public on environmental matters. Awareness-raising campaigns are often most successful when they are targeted at specific groups because information can be tailored to the activities, needs and challenges of the group. A good example of an online resource targeted at educating young people is 'Aquatic Invaders', developed by the Queensland Fisheries Service as an education module available online[64] for teachers of upper primary and lower secondary students.

There is much scope for involvement of children and youth in introduced animal monitoring and management. Young people comprise nearly 30 per cent of the global population and will be the decision-makers of the future.[65] Their way of thinking about the environment is already shaping the world of tomorrow and, just as importantly, can shape the views of their parents. Therefore, it is important that community education and awareness of managing introduced animals at wetlands is inclusive of a range of age groups and is extended to all demographic groups. A good example of a hands-on education campaign targeted at high school students is presented in the case study 'Restocking native fish in Masons Gardens Lake, Dalkeith' at the end of this topic.

Activities aimed at raising community awareness may be as simple as installing signs at a wetland informing the public of the impacts of introduced animals. Alternatively, printed material with information on the effects of released and abandoned pets on the environment could be provided to local pet shops for distribution to customers. Collaboration could also be gained from pet shop owners by asking them to commit to accept any unwanted pets as an alternative to 'releasing' them. The Perth Cichlid Society (www.perthcichlid.com.au) offers to take care of any unwanted fish and provides a list of local fish stores that have agreed to accept unwanted fish.

Raising awareness of the issues and management methods relating to introduced animals in wetlands can encourage greater community participation in management actions as well as prevention. Involving organisations and communities in introduced animal management can create a sense of stewardship towards the wetland, ease hardship through collaboration, and provide a forum for new ideas and greater participation.

Communities can be involved in all aspects of managing introduced animals within a wetland. For example, eastern gambusia were discovered by Waterwatch volunteers in Ilparpa Swamp south of Alice Springs in 2000. This discovery allowed the volunteers to quickly remove the eastern gambusia from the wetland before they became a problem.[66]

Since then, Waterwatch has been educating the community about the impacts of releasing pet fish into waterways and wetlands. The local community continues to be vigilant for new incursions of eastern gambusia. This example shows the importance of ensuring members of the public are capable of correctly identifying introduced animals, even if they have not occurred in the area previously. It also reiterates the value of creating a sense of 'ownership' of a wetland.

Endemic: naturally occurring only in a restricted geographic area

Legislation

There are a number of legal avenues available to prevent introduced animals from becoming established at a wetland. These range from legislation at the state government level, through to local government authority laws, and privately enforced regulations within residential developments.

State legislation

At present the key legislation for preventing the introduction and spread of certain animal species is the *Agriculture and Related Resources Act 1976* (ARRP Act), which is administered by DAFWA. The Act provides for the management, control and prevention of certain animals, for the protection of agriculture and related resources generally. In particular, it categorises a range of introduced animals, known as 'declared animals', into one of six possible categories, each with a corresponding requirement of management, control or prevention.

➤ The list of declared animals is available on DAFWA's website (www.agric.wa.gov.au).[67]

The AARP Act is one of seventeen existing Acts that will be replaced by the *Biosecurity and Agriculture Management Act 2007* (BAM Act). While the BAM Act has been enacted, its regulations and other subsidiary regulatory instruments are not yet in place. One of the main purposes of the BAM Act is to prevent new animal and plant pests and diseases from entering WA, and to manage the impact and limit the spread of those already present in the state. The application of the BAM Act covers biosecurity threats to agricultural activities, as well as threats to the environment, to public safety and amenity, to fishing and pearling activities, and to commercial activities related to agriculture, fishing and pearling.

Controls on the introduction and spread of introduced fish and crayfish are governed by the Fish Resources Management Regulations 1995, which is administered by the Department of Fisheries. Under Regulation 176 of the regulations it is illegal to introduce any fish into a site where the species is not **endemic** without the written authority of the Chief Executive Officer of the Department of Fisheries. Translocation of non-endemic fish without written authority may incur a significant penalty. Fish listed as noxious must not be kept in a person's possession and cannot be released, relocated or kept alive. If caught they must be destroyed.

➤ The list of fish species that are restricted for importation and spread (the 'noxious fish' list) is available from the Department of Fisheries website (www.fish.wa.gov.au).[68]

In 2009, the state government proposed the introduction of statewide cat control legislation to assist in reducing the number of unwanted cats in WA. In mid-2010 the Department of Local Government initiated public consultation on a domestic cat act.[69] This follows on from the disallowance of the City of Joondalup's *Cats Local Law 2008* by the Legislative Council in 2009 on the basis that some of the law's provisions should be applied on a statewide level rather than be isolated to a single local government area, notably in relation to the compulsory sterilisation of cats.[70]

Local government controls

At the local government level, some legal restrictions can be placed on domestic animal owners to register and identify their pets (using tags or microchips), limit the number of certain animals per household, prevent the release of these animals and reduce the impacts of straying animals.

Local governments can use one or more mechanisms at their disposal to place restrictions on domestic animals near environmentally sensitive areas. Local laws can be instated. For example, 'cat prohibited areas' are designated under the *Keeping and Control of Cats Local Law 1999* within the City of Stirling. Wetlands identified as cat prohibited areas include Star Swamp, Carine Swamp, Lake Gwelup, Herdsman Lake and Jackadder Lake (Figure 7).

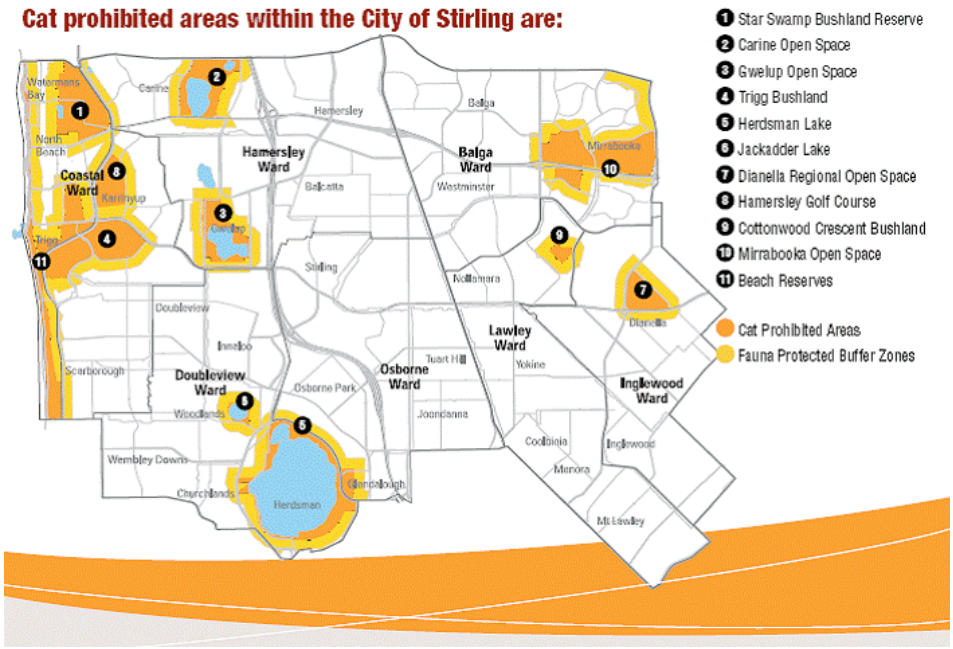

Figure 7. Cat prohibited areas in the City of Stirling.[71] Image courtesy of the City of Stirling.

Alternatively, controls within local planning schemes may be used. For example, a number of areas within the City of Albany are zoned as 'conservation zone' in the City of Albany *Town Planning Scheme No. 3*. Cats and rabbits may not be kept within these areas on the basis that they pose a threat to native flora and fauna.

Many local councils currently encourage voluntary sterilisation of pet cats and dogs by offering subsidies for the procedure.

Private residential developers may place a restrictive covenant on their land that places restrictions on keeping animals. Churchman Book Estate, within the City of Armadale, has prohibited the keeping of cats on the land. This covenant has been put in place to prevent pet cats from roaming and hunting wildlife in the nearby Armadale Settlers Common, an environmentally sensitive area. However, restrictive covenants generally have an 'expiration date' after which time the restrictions lapse.

While creating and implementing legislation may be beyond the scope of wetland managers, they may lobby local and state government for the establishment of laws regulating key problem species. Introduced animals may be controlled by limiting their movement, restricting ownership and by requiring sterilisation.

Physical barriers

An effective way to prevent introduced animals from damaging a wetland is to prevent them from entering altogether. Constructing physical barriers is often the simplest and most effective way to combat introduced animals. Of course, barriers are only effective if they serve to keep introduced animals out, not in. If breached, barriers may actually increase the risk of vulnerability of endangered fauna species by preventing their escape from the predator. If introduced animals are found within the confines of a barrier, it may be necessary to remove them using the methods discussed later in this topic. Continual monitoring for new incursions is essential.

A range of barriers is available, including fencing, screens and netting, depending on the animal being targeted. Fencing is the most commonly utilised type of barrier.

Fencing

There is a myriad of fence designs available for use in excluding introduced animals. The type of fence chosen will depend on the type of animal to be excluded. It is generally understood that no fence will be 100 per cent effective all of the time. Electric wires may be used to improve the effectiveness of this barrier but are rarely a successful deterrent on their own. Fences may be damaged by large animals or by falling vegetation and so monitoring, maintenance and repair of the fencing will be required. The base and corners of a fence, as well as gates and waterway crossings, are often the weak points of a fence that will be exploited by introduced animals. Special attention should be paid to ensure these features are maintained and are functional. The high costs of establishing and maintaining some types of exclusion fencing, such as feral cat-proof enclosures, generally limit their use to the management of threatened or endangered species, such as the protection of the endangered western swamp tortoises (*Pseudemydura umbrina*) at Twin Swamps and Ellen Brook nature reserves in Bullsbrook and Upper Swan respectively.

- For more information on the types of fencing that can be used to exclude foxes and feral cats, rabbits, goats, pigs and wild dogs, see the *Catalogue of fence designs* available on the Department of Sustainability, Environment, Water, Population and Communities website.[72]

- For more information on fencing suitable for camels, see *Camel control using alternative fencing* available on the Northern Territory government website.[73]

A fence should provide an effective physical barrier to the targeted introduced animals while minimising detrimental effects on the native fauna of the area. Generally the fence should be placed at a distance from the wetland. This will allow native fauna to use both the wetland and adjacent dryland if required. For example, female oblong turtles (*Chelodina colliei*) can lay their eggs at some distance from wetlands (the distance varies). If the fence is placed too close to the wetland, they may die from dehydration or predation while persisting in their efforts to get past the fence to their intended nesting site.[74] Similarly, if fences are too close to the wetlands, they may be within the flight path of large birds, increasing their risk of entanglement.

Fencing can alter or restrict the movement of native fauna in and out of a wetland, alter their dispersion and foraging patterns, and cause entanglement and electrocution. It can also create a significant hazard to wildlife in the event of a bushfire.[75] Mesh, barbed, plain and electric wire fences have caused injuries and deaths of bats, kangaroos, wallabies, small mammals, waterbirds, birds of prey and owls. Wetland fences can pose a higher risk of entanglement or injury when they are new, where they cross animal flight paths and tracks into a wetland and where they are less visible at the boundary between low pasture and taller native vegetation. The top and bottom wires are where animals most often come in contact with the fence, with small animals such as echidnas and snakes being killed by electrified wires close to the ground. These problems can be

minimised by choosing a fence type and location that increases fence visibility and by installing native animal access ways, such as gates. In areas where entanglement is a problem, fence visibility can be increased by attaching metal tags, old CDs, tin cans or aluminium pie dishes to the top two wires.

➤ For more information on ways to reduce the impact of fences on native species, see *Wildlife Friendly Fencing Guidelines*[76] and DEC Fauna Note 32 *Fencing and gates to reduce kangaroo damage.*[77]

Screens and nets

Where a waterway (such as a creek, stream or river) or drain flows into a wetland, barriers in the form of large screens or mosquito nets may be fitted to prevent the movement of introduced fish. Screens and netting may also not be effective for juveniles or eggs as these will still pass through the barrier. Sometimes, such barriers may be teamed with traps to remove introduced fish from a waterway (see the section 'Fish traps' for more information). A number of screens are currently available such as vertical travelling screens that remove debris whilst preventing passage of a range of fish sizes. These options are currently being assessed to control downstream colonisation of the pearl cichlid from wetlands on Bennett Brook and Ellen Brook (S. Beatty pers. comm.).

Control

It is very difficult to completely prevent introduced animals from entering a wetland, particularly if they are terrestrial or highly mobile. In some situations, the most feasible option may be to carefully monitor the wetland and promptly remove any new intruders before the introduced animals have a chance to start reproducing and to become established. Therefore, a key component in preventing the establishment of introduced animals at a wetland is appropriate surveillance. Wetlands should be observed for signs of newly occurring introduced animals as often as possible, whether it be on a casual or opportunistic basis, or as part of a dedicated monitoring program.

➤ For information on designing a monitoring program, see the topic 'Monitoring wetlands' in Chapter 4.

Once an introduced animal has become established at a wetland, and is having an impact either on the wetland itself or on the native animals that reside there, the best course of action is to remove the animal in question from the wetland. Introduced animals may be controlled by:

- trapping
- shooting
- poisoning
- fumigating
- using shockwaves
- electrofishing
- manipulating habitat or food
- removing the animals manually
- using fertility control.

The choice of the best method of removal will depend on the animal itself as well as factors such as the environment in which they are found (for example, open or closed vegetation) or population size. In some cases, such as the control of rabbits, a combination of removal methods may be necessary. The eradication or removal of introduced animals may not always be possible; for example, there is no approved method of removing introduced aquatic invertebrates such as brine shrimp. This reaffirms the importance of prevention when managing wetlands for introduced animals.

In some scenarios, the control options available may be more environmentally damaging than the introduced species being controlled. This can be the case where non-target impacts of the control method are high even when carried out by a professional, for example, the use of some pesticides, the creation of shockwaves at some wetlands and the removal of some habitats. A proposed control activity which, if implemented, is likely to have a significant impact on the environment, requires referral to the Environmental Protection Authority, in accordance with the *Environmental Protection Act 1986*. A careful risk analysis should always be undertaken, considering the following:

- What are the values under threat from the introduced species?
- What are the potential off-target impacts to the wetland of each relevant form of control? How can the potential off-target impacts be minimised?
- Do the potential off-target impacts outweigh the benefits of control of the introduced species?

Many of the control options also require forethought regarding the handling and disposal of carcasses. Carcasses should never be buried within or close to wetlands, other aquatic environments or drinking water catchments due to the risk of contaminating the water, nor close to roads due to the road safety risks posed.

Nocturnal: primarily active during the night

Trapping

Trapping may be used to control most introduced animals but can be time consuming and labour intensive and is therefore best suited for control of small populations or individuals. The success of trapping will depend on the species being targeted and the design of the trapping program. The choice of appropriate traps and trap sites will maximise the chance of capture and also minimise the distress caused to any animal caught, be it target or non-target. The use of some types of traps requires authorisation; see Table 2 for more information on the authorisations required.

Traps should be set in a place where the targeted animals are most likely to encounter the trap. Attractants such as edible bait, odours or sounds may be used to lure the introduced animals into the trap. The type of bait used will depend on the diet of the introduced animals. Meat baits such as chicken wings are appropriate for carnivores and most other mammals will be attracted to 'universal bait' (a mixture of rolled oats, peanut butter, honey and sometimes sardines).

Traps will need to be checked often (at least in the morning and late afternoon) to prevent suffering from heat, thirst, starvation, exposure or shock. The trapped animal will be stressed and may injure itself while trying to escape. Frequent checking is particularly important where non-target fauna may be caught (which is likely in most cases). To minimise non-target fauna being caught, traps should be opened to correspond with the time of day the target animals are active. For example, if **nocturnal** animals are being targeted, traps should be opened shortly before sunset and checked as soon as possible after sunrise.

Once caught, the animal may be humanely euthanased. Traps may potentially cause significant suffering or even death and so care should always be taken to ensure the welfare of the trapped animal. This is particularly important to ensure non-target native animals are released unharmed. Traps should always be placed to avoid exposure to the elements, particularly heat or direct sunlight, flooding and predation (including predation by ants). Shade cloth or hessian can be wrapped around wire cages and aluminium folding traps to provide shelter. Some bedding material can also be provided in traps to provide protection from cold weather. The location of all traps should be accurately recorded and marked, and the information readily available in case the trapper is unable to check the traps. It is also important to check each trap every time it is set to ensure it is functioning properly.

There are several different types of traps available. The trap should be selected based on how suitable it is for the species being targeted and the trapping location, as well as logistical factors. Table 5 identifies which traps are suitable by species.

Table 5. The types of traps most suitable for capture of introduced animals affecting wetlands

Introduced animal	Trap yards	Wire/steel cage traps	Aluminium folding traps	Jawed traps	Fish traps	Nets	Basking turtle traps	Cane toad traps
Domestic waterfowl						•		
Cane toad								•
Red-eared slider turtle						•	•	
Introduced fish					•	•		
Introduced crayfish						•		
Cat		•						
Red fox		•		•				
Domestic dog				•				
Camel	•							
Horse	•							
Donkey	•							
Goat	•							
Pig		•						
Rabbit		•		•				
Rodents			•					

Euthanasia of trapped animals must be conducted humanely and legally and cause no suffering to the animal. In order to achieve this, the people undertaking these activities must be competent and, where necessary, licensed to do so.

➤ See *Methods of euthanasia*[78] for suitable techniques for euthanasia of trapped introduced fauna.

Holding yards

Holding yards are used for capturing and holding very large animals such as camels, horses, donkeys and goats for short periods. Holding yards may be fixed or portable. Mobs and herds of animals can be mustered (herded) to holding yards. Additionally various attractants, such as food or water, can be used to entice the animals into trap yards, a form of holding yard. Once in a trap yard, the animals can be trapped by using 'spears' or a trip wire to close the gate. Spears made of steel pipes or timber saplings are held up by wires at the gate. The spears point inwards into the yard. Animals may push their way through the spears which will move sideways slightly, but when they try to leave the yard the spears will point against them.

➤ Standard operating procedures for mustering and trapping feral horses and goats are available from the Department of Sustainability, Environment, Water, Population and Communities website.[58]

➤ A model code of practice for the destruction, capture, handling and marketing of feral livestock is available online from CSIRO.[79]

Wire or steel cage traps

Wire or steel mesh cage traps are available in a variety of sizes, from traps suitable for rats or rabbits (although these are unlikely to enter a trap) to those large enough for pigs. For example, a dog-sized cage is 120 x 60 x 60 centimetres and is made of 2.5-millimetre welded wire with a mesh size of 50 millimetres. There are two types of cage traps: treadle-activated and hook-activated. Treadle-activated traps have a metal plate at the base of the cage which is connected to the cage door. When an animal steps on the treadle, either a hinged swing-style or a drop down guillotine-style door will close shut. The other type involves the bait being placed on a hook. When the animal pulls on the hook, it triggers the door to close behind the animal.

Foxes, feral cats and wild dogs are very wary of entering cage traps. However, the use of cages to trap feral pigs has been found to be quite successful. DAFWA identifies panel, box and silo traps (Figure 8) used with vertical, side-hinged and funnel gates as suitable for use in trapping feral pigs.

- For DEC's standard operating procedures for cage traps, see *Standard Operating Procedure 9.2 Cage traps for live capture of terrestrial vertebrates*.[80]
- For information on traps suitable for feral pigs, see DAFWA's Farmnote No. 36 *Feral pig control by trapping*.[81]

Figure 8. Pigs trapped in a silo trap with a funnel gate (also referred to as a 'figure 6 trap') in a wetland in the Lake Muir – Denbarker area of Western Australia. Photo - Lake Muir/Denbarker Community Feral Pig Eradication Group.

case study

Fighting feral pigs on the south coast

Feral pigs (*Sus scrofa*) are found in many parts of WA, particularly in the south west and the Kimberley. They favour a wide range of habitats in medium to high rainfall areas and require thick vegetation cover and access to water[82], so are often found in and around wetlands.

Feral pigs cause considerable damage to natural environments such as wetlands through rooting and trampling, which causes physical damage and erosion, and destroys soil fauna (Figure 9). Rooting also reduces ground cover and can cause vegetation change and open areas for weed invasion. Feral pigs consume plants, prey on native fauna (such as frogs, small mammals, reptiles, insects, worms and birds), destroy their habitat and out-compete them for habitat and food. They wallow in wet areas, churning up sediment and fouling the water with faeces and urine. Recent studies also suggest feral pigs can facilitate the spread of the *Phytophthora cinnamomi* pathogen responsible for Phytophthora dieback, as well as other pathogens and diseases.[82]

Figure 9. Evidence of pig damage at a wetland in Pingrup. Pigs cause wetland soil erosion and compaction, providing suitable conditions for introduced weeds to invade. Photo – M Barley/DEC.

Plants that have tuberous roots and which grow in wetlands, such as sundews (*Drosera* spp.) (Figure 10) and orchids (such as *Caladenia* spp.), are often impacted by feral pigs.[83] Large pigs will dig furrows up to 20 centimetres wide throughout feeding sites to dig for tubers and roots. Such behaviour causes erosion and soil compaction, forms trails and destroys wetland vegetation. It appears feral pigs are particularly attracted to sensitive areas of a wetland located around surface water following germination of spring flora species.[84]

Figure 10. *Drosera huegelii*, a species of sundew from the south-west of WA, is eaten by feral pigs. Photos – C Hortin and E Wajon. Image used with the permission of the Western Australian Herbarium, DEC (http://florabase.dec.wa.gov.au/help/copyright), accessed 12/05/2010.

Wetland fauna are threatened by feral pig invasion. Pigs destroy the habitat of species such as quokkas and bandicoots that require dense vegetation for protective habitat. Frog species, such as the sunset frog (*Spicospina flammocaerulea*) found in isolated peat wetlands in the Warren Region north of Walpole and Denmark (Figure 11), are at risk from habitat destruction and being eaten by pigs.

Figure 11. The sunset frog (*Spircospina flammocaerulea*), which is threatened by feral pigs. Photo – K Bain/DEC.

case study

Community action

In 2001, a number of local landholders in the Lake Muir and Denbarker area recognised the growing threat of feral pigs to the south-west and decided to undertake a pilot eradication project in the area, which supports natural areas of high conservation value including the Frankland River and the Ramsar-listed Lake Muir.

The success of the trapping program during the five-month pilot demonstrated the benefit of the project and the Lake Muir/Denbarker Community Feral Pig Eradication Group was formed.

Collaborative action has been a cornerstone of the group's success. A range of project partners and stakeholders have been involved, including local landholders; DAFWA and DEC; South Coast NRM Inc; Green Skills Inc; the shires of Denmark, Plantagenet, Manjimup and Cranbrook; Great Southern Limited; ITC Limited; Walpole-Nornalup National Parks Association and the Wilson Inlet Catchment Committee Inc.

This integrated stakeholder approach has been highly successful in identifying and eradicating feral pig populations, because it combines resources and provides opportunities for coordinated management across property boundaries.[83]

The group's committee has found that trapping is the most appropriate method for the Lake Muir/Denbarker area (Figure 12) and that trapping is most efficient in late summer to early autumn, when water and feed supplies are low. A 'figure 6' silo trap is generally most effective at catching a group of pigs at a time, complemented by traps with a drop gate for pigs too large to enter the figure 6 traps. To maximise trapping success, pre-feeding is employed to encourage pigs to become accustomed to traps prior to trapping. The experience of the group is that inadequately controlled shooting and hunting poses a risk of scattering pigs and training them to avoid humans. The group reports that shooting by organisations such Sporting Shooters' Association of Australia complements trapping, however, communication between organisations has been vital to minimise duplication of effort and disturbance to each other's programs.

Figure 12. Feral pigs trapped by the group. Photo – Lake Muir/Denbarker Community Feral Pig Eradication Group.

The coordinated trapping approach is contributing significantly to the reduction of feral pigs in the area. In the 2007 and 2008 seasons, 225 pigs (including sows carrying a total of 165 unborn pigs) were dispatched.[84] In 2009, 169 pigs were dispatched. This high number reflects refinements in tracking and trapping techniques as well as the addition of new areas under trapping (M Muir 2010, pers. comm.). In autumn of 2010, 139 pigs (including sows carrying 75 unborn pigs) were dispatched.

Despite successful control of local populations of feral pigs, re-invasion is a constant threat because illegal dumping still occurs and because feral pigs can travel significant distances. The group therefore maintains a long-term perspective, with ongoing monitoring and treatment of areas remaining a priority.

The group has seen many advances in the fight against feral pigs since its formation in 2001. A number of groups have formed to fight feral pigs in other areas, and the Southern Feral Pig Advisory Group has recently been formed as an 'umbrella group' for these groups. In addition, a pilot nationally recognised training course has been developed to provide accreditation for feral pig trappers. These initiatives support the ongoing fight to control feral pigs in WA.

For more information on the Lake Muir/Denbarker Community Feral Pig Eradication Group, go to www.feralpig.southcoastwa.org.au.

Note: this case has been prepared in consultation with the Lake Muir/Denbarker Community Feral Pig Eradication Group.

Aluminium folding traps

Aluminium folding traps, often called Elliott traps after the manufacturer, are small metal boxes that are easily folded up when not in use (Figure 13). Aluminium folding traps operate on a treadle mechanism. The hinged door folds inwards to allow the animal to walk over it and onto the treadle. The door then springs shut, trapping the animal. Aluminium folding traps are small and come in two sizes: A and B. These traps are mainly used for capturing small mammals such as house mice.

Figure 13. A typical set-up of an Elliott aluminium folding trap covered hessian. The trap is placed in a shady position under vegetation cover. Photo – A Nowicki/DEC.

➤ For DEC's standard operating procedures for Elliot traps, see Standard Operating Procedure 9.1 *Elliott traps for live capture of terrestrial vertebrates*.[85]

Jawed traps

Jawed traps can be used to trap foxes, rabbits and wild dogs. Foxes and wild dogs are very wary of entering cage traps, and so the use of jawed traps may achieve a higher success rate than cage traps. Even so, jawed traps are generally considered to be an ineffective tool for general population control of foxes, rabbits and wild dogs; they are generally used to control small, isolated populations, hard-to-catch individuals or following a baiting program.[86,87,88,89] Furthermore, as with most traps, jawed traps are not target-specific and can catch animals such as birds, kangaroos, wallabies, echidnas, goannas, wombats, possums, bandicoots, quolls and sheep[88]; as well as humans, therefore the decision to use jawed traps should take this into account.

The main benefit of jawed traps is that the animal is unaware of the trap until it is caught. The traps are buried into the ground in the set position. They operate by snapping two 'jaws' shut when an animal steps on the treadle plate or 'pan'. The pan is usually adjustable to suit the animal being targeted.

Jawed traps come in two main types: leg-hold and foot-hold (often called 'soft-catch'). The difference between leg-hold and foot-hold traps is that leg-hold traps are much larger and often catch the animal higher up on the leg, which can cause major trauma. Foot-hold traps seize the animal across the tougher padded area of the foot and are therefore preferred.

Jawed traps have evolved substantially since the early steel-jawed models. The traps in use today have padded, offset and/or laminated jaws. Offset jaws have been altered to leave a gap between the trap jaws, allowing greater blood flow to the animal's foot. Laminating traps expands the thickness of the trap which increases the surface area of the jaw on the animal's foot. Doing so reduces the injury caused to the trapped animal and also increases holding efficiency. Only padded-jaw traps can be used for fox and rabbit control.[88,87,86] For trapping of wild dogs, traps that cannot be serviced daily must be wrapped in hessian that is impregnated with strychnine crystals to prevent prolonged suffering.[89]

➤ Standard operating procedures for trapping of foxes, rabbits and wild dogs using jawed traps are available from the Department of Sustainability, Environment, Water, Population and Communities website.[58]

Fish traps

It is important to seek advice from the Department of Fisheries before attempting to use any equipment, including traps, to catch introduced fish or crustaceans within Western Australian wetlands. An exemption from the department is required for trapping activities.

Generally, fish traps and nets are considered to be relatively ineffective for eradicating introduced fish and crustaceans. This is because the biology of most introduced species makes the containment of such organisms, especially their reproductive material, extremely difficult (B Bardsley 2010, pers. comm.).

However, traps may be used to significantly reduce introduced fish populations. Box-mesh traps, like the one shown in Figure 14, can be used in wetlands to trap introduced fish such as eastern gambusia (*Gambusia holbrooki*). These were used by students of Shenton College to trap and remove eastern gambusia in Dalkeith (for more information, see the case study 'Restocking native fish in Masons Gardens Lake, Dalkeith' at the end of this topic).

Figure 14. A box mesh trap used to capture eastern gambusia. Photo – C Lawrence/Department of Fisheries.

Both the design and placement of fish traps can help reduce the entrapment of non-target species. For example, it is important to ensure that the trap opening is small enough to exclude turtles from entering.

Traps such as carp separation cages can be used to catch introduced fish in waterways or drains feeding into wetlands. The carp separation cage encourages European carp (*Cyprinus carpio*) to jump over a wall into a separate trap with a hinged lid, preventing escape. Recent laboratory trials of a 'finger style' carp push trap in South Australia have shown promise as a carp management option.[90] Cages and barriers may be used together to improve introduced fish management (see 'Barriers' for more information).

Nets

There are three main types of nets that can be used to catch introduced animals within wetlands: hand-held nets, mist-nets (for birds) and netted traps (for water-dwelling animals). Hand nets consist of conical netting attached to a hoop on the end of a rigid handle. The use of a hand-held net is fairly labour-intensive and so a netted trap or mist-net may be preferred.

Mist nets and netted traps are stationery. Steps should always be taken to ensure that these traps can easily be located. For underwater traps, this may be achieved by attaching a buoy to the trap. Careful consideration of non-target animals is required when using netted traps.

Mist net traps are fine nylon or polyester nets which are suspended between two upright poles. The grid size of the mesh netting varies according to the size of targeted birds. The net is practically invisible to birds, which fly into the net and remain caught until released. Birds will entangle themselves in the net and so continual monitoring and expert handling of caught birds is required. Mist nets have a high likelihood of non-target capture, further emphasising the need for frequent surveillance.

Netted traps come in a variety of designs including drop nets, hoop nets, yabbies pots or turtle traps. All designs consist of a rigid frame covered in mesh netting. The traps may be baited. Care should be taken when hauling a trap out of water to avoid disturbing the wetland sediment. Drop nets are constructed from two hoops joined by a cylindrical or cone-shaped net bag. Introduced crayfish are generally trapped with drop nets. Hoop nets are similar to drop nets but only have one hoop with a conical-shaped net attached to it. Yabbie pots are constructed from rigid wire and netting and have two fixed entrance funnels. They come in two shapes: rectangular and 'opera house', which is a semi-circular design. Opera house traps must be used with extreme care, as they can entrap rakali, also known as native water rats (*Hydromys chrysogaster*), which drown if caught. It is important to seek advice from the Department of Fisheries before attempting to use any equipment, including nets, to catch introduced fish or crustaceans within Western Australian wetlands. An exemption from the department is required for trapping activities. In 2007 the Minister for Fisheries granted an exemption for the use of fish traps within Lake Kununurra to allow commercially available 'opera house' style traps, specially modified to target redclaw, to be used to trap the introduced freshwater crayfish redclaw (*Cherax quadricarinatus*).[91]

Turtle nets are similar to yabbie pots but have been modified to allow turtles to reach the surface of the water to breathe air. Turtle nets are collapsible with a rectangular frame, two entrance funnels, and netting.[92] The netting forms a cylindrical shape and extends upwards by about 2 metres. The upper end of the cylindrical netting is tied with a cord to a tree branch or a stake above the water surface, allowing the trapped turtles to swim for air while remaining trapped.

Basking turtle traps

As well as the netted trap design outlined above, there are several basking trap designs and most consist of a floating basking platform with a net or wire basket attached underneath.[93] Turtles climb up the sides of the trap to bask on the platform and are captured in the net after leaving the platform. The sides of the trap are sloped inward to facilitate entry and prevent escape.

Cane toad traps

Cane toads may be removed at all stages of their life cycle. While eggs can only be removed by hand, cane toad tadpoles and adults can be trapped.

Tadpoles of any frog species can be trapped using funnel traps placed under water. These come in a myriad of designs, including cylindrical or box traps constructed from mesh galvanised wire, traps made from plastic beverage bottles, collapsible nylon mesh traps, and traps made with acrylic plastic sheet.[94,95,96,97,98] All of these designs operate by allowing tadpoles to enter the trap through one or two funnels, but not allowing the tadpoles to escape.

A variety of traps have been developed for capturing adult cane toads. These are generally cage traps, traps made of solid metal walls, or traps that are a combination of cage and solid walls. Kununurra and Wyndham residents can currently obtain cane toad traps from the Shire of Wyndham/East Kimberley depot for a small deposit for use on their properties.

Although extensive trapping of adult cane toads has been undertaken in the Kimberley, a number of issues have been identified with this method. These include maintenance and service of traps in remote areas; damage by fire, theft, vandalism, livestock and wildlife; capture of non-target species; and the need to position traps very close to or in water. DEC recognises that cane toad traps may play a role as a surveillance tool at and ahead of the main front and may be required by community members as a tool to keep toads out of backyards. To maximise their effectiveness, a combination of lights, baits and acoustics (that is, playing toad calls in order to attract others) is recommended to attract cane toads to the traps.

The use of fences may also improve the effectiveness of cane toad traps. Deflection fencing, which involves a barrier set up to direct toads towards traps, has been trialled for the control of cane toads (Figure 15). While the specific fence design and application are still being developed, temporary barrier fencing may also play a role in the exclusion of cane toads from strategic sites that are of special significance such as mound springs.

➤ For more information on the control of cane toads, see the DEC website at www.dec.wa.gov.au/canetoads.

Figure 15. Deflection fencing in use during the Stop the Toad Foundation's 2009 'Great Toad Muster'. Photo – A Shanahan.

Shooting

Nuisance kangaroos and larger introduced animals, such as camels, goats, horses, pigs, foxes, cats, rabbits and even red-eared slider turtles may be shot. In most cases, this will be lethal to the animal. Tranquiliser guns may be used if the aim is to translocate the animals, which may be an option for nuisance kangaroos. This can be expensive, with prices around $1,000 per kangaroo quoted in the metropolitan area of Perth. Shooting may be conducted on the ground. Aerial shooting is best suited for large-scale population control, particularly in remote and/or inaccessible areas. A team is required for aerial shooting, including a shooter, a pilot and a spotter/counter who locates the animals and records the number of animals shot.

Shooting can be a humane method of introduced animal control when it is carried out by experienced and skilled shooters (and pilots in the case of aerial shooting). Introduced animals should only be shot when they can be clearly seen and are within range, and using the correct calibre firearm and ammunition. Correct shot placement (aiming for the brain or heart) is very important and wounded animals should be promptly located and killed.

➤ Standard operating procedures on how to humanely shoot introduced animals species are available from the Department of Sustainability, Environment, Water, Population and Communities website.[58]

If carried out correctly, shooting can be the most humane method of removing introduced animals. It is also one of the most cost-effective methods available, particularly when population densities are high. However, shooting is often only a short-term solution and may have to be combined with other management methods such as exclusion fencing.

case study

Managing the nuisance kangaroo population at Thomsons Lake Nature Reserve

Kangaroos are prolific breeders and, due to a reduction in predation and a greater availability of food on cleared land, are able to quickly increase in population size until they can no longer be supported by the habitat.[99] Kangaroos form nuisance populations at golf courses, ovals and on farmland but generally they are not a major issue at wetlands. Large populations of kangaroos can readily form when they are unable to disperse due to fencing or insufficient corridors of native vegetation. In recent years, this has occurred at Thomsons Lake Nature Reserve in southern metropolitan Perth, which is fenced to protect waterbirds from predation by foxes and cats. Following the installation of the vermin-proof fencing in 1993, the population of western grey kangaroos (*Macropus fuliginosus*) within the reserve increased from twenty to thirty individuals to approximately 1,100 kangaroos by 2006. The kangaroos were causing extreme harm by overgrazing the understorey of the wetland and dryland vegetation. Kangaroos were culled (shot) in 2006 in accordance with the kangaroo management program for the reserve[100] and with the approval of the Conservation Commission of Western Australia and the support of the community-based Beeliar Regional Park Community Advisory Committee.[101] Translocation of the kangaroos was considered but rejected on the basis that it was not a feasible or practical option because of the unacceptable level of stress it would place on the animals, as well as causing unnatural pressures on any areas to which they could be relocated.

Poisoning

Poison may be applied within and around wetlands in two forms. The poison may be applied either directly, a method mainly used for controlling introduced fish and aquatic invertebrates; or through bait delivery, a method mainly used for terrestrial mammals.

When using poisons

Any chemical or biological agent intended to kill animals, such as a poison, is a **pesticide**. Extreme care must be taken to ensure that the use of pesticides does not constitute an offence or cause environmental harm. In WA, anyone who uses pesticides is bound by the Health (Pesticides) Regulations 1956. These regulations were developed to provide protection for the applicator, the public and the environment from misuse of pesticides. Pesticide labels are written in accordance with the Regulations and therefore any pesticide user has a legal obligation to read and follow instructions on the label. By law and without exception, pesticides cannot be used in any manner contrary to that described on its label without the permission of the Australian Pesticides and Veterinary Medicines Authority.[102] The label provides instructions for use, for the protection of the environment, information about storage and disposal and recommendations for personal protective equipment. Anyone proposing to apply a pesticide to a natural area of conservation value should have appropriate authorisation and should undertake training in the correct preparation, handling, application, transport and storage of pesticides. Legislation regarding the use of chemicals is under review and in future this may become a legal requirement.

Direct application

Rotenone

The most common poison used to control introduced fish is rotenone. Rotenone is an odourless chemical which occurs naturally in the roots and stems of several plants such as the jicama vine plant.[103] Commercial products containing the extract are used to poison fish, which are then easily collected because they swim to the surface of the water seeking oxygen.

Rotenone is primarily used for the control of introduced fish. However, it is a broad-spectrum pesticide, that is, it is toxic to many species including a number of aquatic fauna, such as tadpoles and a range of aquatic invertebrates. Rotenone is mildly toxic to humans and other mammals. This higher toxicity in fish and insects is because rotenone is easily taken up through the gills or trachea, but not as easily through the skin or through the gastrointestinal tract. The compound breaks down when exposed to sunlight. Rotenone persistence in natural waters is reported to vary from a few days to several weeks, depending on the season.[104] Rotenone is widely considered to have only minor and transient environmental side-effects and is considered by many researchers and institutions to be the most environmentally friendly fish poison.[104]

At this time, most methods of introduced fish control are unable to exclusively target a single species. As such, native fish will be at risk when controlling introduced fish. There has been some research into developing rotenone in bait form, which could then be targeted at individual species such as carp.[105] However, this method still requires further development.

In Australia, rotenone can only be used as a **piscicide** if permission to do so is granted by the Australian Pesticides and Veterinary Medicines Authority in the form of a 'minor use' permit (see Table 2 for more information). In the United States of America, where rotenone has been in use for many years, the American Fisheries Society has recently published standard operating procedures for the use of rotenone.[106] The New Zealand Department of Conservation has published a review of rotenone which includes a recommended protocol when considering its use as a piscicide.[104]

Piscicide: a chemical substance which is poisonous to fish

A proposal to use rotenone requires an environmental assessment as to whether it is acceptable at a particular wetland. As with any pesticide, the risk to all fauna needs to be identified and considered as part of this assessment. Important risk factors include whether the wetland is open or closed (that is, there is no overland flow into or out of the wetland); whether native fish and other susceptible native species may be present; and timing of the application to reduce impacts on native fauna present (for example, rotenone is known to be more toxic to tadpoles than adult frogs).[107] Another option to minimise the impacts on native fauna is to ensure that native species are removed from the control area for later restocking, or that there are nearby breeding populations which can naturally repopulate the area.[108]

➤ The use of pesticides and the removal and reintroduction of freshwater species is subject to regulation. For more information, see Table 2 and the section of this topic entitled 'How to manage the impacts of introduced animals'.

Among other methods, rotenone was successfully used in the control (but not eradication) of pearl cichlids (*Geophagus brasiliensis*) in the Perth metropolitan area. The cichlids were first discovered in March of 2006 and steps were taken to limit their spread in a range of water bodies at Altone Park, the Altone Park Golf Course irrigation ponds, drainage systems and natural streams such as Bennett Brook.[109,110] Rotenone has also been successfully used to control and eradicate populations of goldfish from billabongs near the Warren River and the Margaret River (S. Beatty pers. comm.).

Baiting

Baiting is an option often favoured for the control of foxes and rabbits. Baits may also be used for the control of introduced mice and rats. Baiting techniques for feral cats have improved rapidly in the last decade, however the use of Eradicat® in WA is currently limited to an experimental permit by DEC.

The primary method of control of foxes is by spreading baits containing the compound 1080 (sodium monofluoroacetate). There are two types of 1080 baits: dried meat baits and sausage baits. Meat baits are made by injecting 1080 into various meats (usually kangaroo or horse meat) which are left to sun-dry until at least a hard crust forms. Sausage baits are semi-dry meat baits whereas the traditional dried meat baits are fully dried. Spreading 1080 baits for fox control can be done by manually laying out the baits along set transects or by mass aerial dispersal. Baiting is an effective way of controlling foxes as they readily scavenge and frequently take up baits.[115,38,116] There has been substantial research in improving the effectiveness and safety of 1080 baiting in Australia including assessing the attractiveness and palatability of various types of baits.[116,117,118]

One of the main concerns when applying any lethal control methods is the impact on non-target species, particularly pets and native species. Native south-west Australian fauna are least at risk of fatalities associated with 1080 bait consumption. Monofluoroacetic acid, from which 1080 baits are derived, occurs naturally in the legume genus Gastrolobium. Over the millennia fauna of the area have co-evolved with the plants to develop a very high tolerance to the compound.[111,112] However, native carnivores and scavengers such as dingoes, quolls, goannas and some birds are at risk of consuming 1080 baits.[113] Some strategies can be employed to reduce the risk of bait uptake by non-target species, for example, by burying the baits to prevent birds from

picking up the baits.[113,114,115] It must be noted that quolls readily dig up baits just as foxes do.[115,116]

➤ The use of baits containing 1080 is regulated. An excellent guide to the use of 1080 is *Landholder information for the safe use and management of 1080.*[62]

Baiting is now recognised as the most effective method for controlling feral cats when there is no risk posed to non-target species.[117] Historically baiting programs for feral cats were ineffective, principally because the baits used were for other introduced predators such as foxes and wild dogs and were unattractive to cats. In response, DEC researchers conducted an extensive series of trials which have led to the development of the feral cat bait known as 'Eradicat®'.[129,130]

Baiting campaigns using Eradicat® have proven to be an effective method in reducing feral cat numbers and it is now used by DEC as a control tool for feral cat management at a number of mainland sites in arid and semi-arid regions.[118] A recent project has gone a long way to demonstrating that the sustained control of introduced predators (both feral cats and foxes) in the southern rangelands can also be achieved using this bait.[119]

Baiting may also be used to control rabbit and rodent populations. The bait material used is either oats or carrots. Poison is then applied to the baits, usually 1080 or Pindone. Pindone is a registered rabbit poison that was originally developed for rodent control and is available in two forms: powder or liquid.[120] Pindone bait is preferred for use in urban and urban/rural areas as it has an antidote, vitamin K1, and is generally safer to use than 1080 where non-target domestic animals are at risk.[121,120,122] However, Pindone poses a greater risk to wildlife than 1080.[120] Therefore, choice of poison will depend on where the introduced animal control is being conducted. Only 1080 should be used where non-target wildlife are likely to be exposed to the bait, or considered to be at risk.

extra information

Baiting for rabbits

Baiting is generally only the first step in rabbit control and should be carried out in conjunction with warren ripping and/or fumigation.

Rabbit baiting is most effective in the late summer/early autumn. This is when natural causes and deliberately introduced viruses used as biological controls (such as myxomatosis or rabbit calicivirus disease) will have reduced the population, food availability is at a minimum, young rabbits are old enough to emerge from their warrens, and the breeding season is over so rabbits will range over greater distances.[121,120] The best area to lay baits for rabbits is close to their warren, however, they do feed up to 400 metres from their warren. The results of a rabbit control program can be greatly improved by laying unpoisoned baits, known as free feeding, once or twice before laying poison baits. Free feeding allows the rabbits to acquire a taste for the baits and encourages them to feed on a new food source.[121,120] Following baiting, all uneaten bait and rabbit carcasses should be collected (for up to 8–12 days following baiting) to make sure non-target animals aren't harmed by ingestion of either the bait or poisoned carcasses.

Fumigation

Fumigation may be used for the control of rabbits either following or as an alternative to warren ripping, which is undertaken after poisoning. Burrows dug out by foxes as shelter for their cubs (natal dens) may also be fumigated. Fumigation is considered to be less humane than poisoning with 1080. Therefore, it is desirable to fumigate only after a poisoning program has been completed, when the density of rabbits or foxes is low.[123]

Fumigation involves the introduction of toxic fumes into a burrow where it is inhaled by the inhabitants, leading to their death. There are two types of fumigation: pressure fumigation, in which the fumigant gases or vapours are generated outside the burrow and are forced into the burrow under pressure, usually from a pump or fan; and diffusion (or static) fumigation, where tablets are placed in active burrows and the gas generated is allowed to diffuse through the burrow.[124,125,123] Toxins used for fumigation include chloropicrin, carbon monoxide, carbon dioxide, calcium cyanide and phosphine.[124]

Phosphine has been widely used for diffusion fumigation and remains the preferred toxin for fumigation of rabbits. Phosphine is a gas which is released from aluminium phosphide tablets when they react with moisture.[125] Damp soil conditions give the best results when using this method of fumigation.[126]

Fumigation with carbon monoxide has been developed as a humane alternative to phosphine.[127] Carbon monoxide gas causes unconsciousness and rapid death without pain or discomfort. Carbon monoxide fumigant cartridges, such as DEN-CO-FUME®, are now registered for use in controlling foxes in natal dens. The cartridges contain carbon and sodium nitrate, which combust to produce carbon monoxide once the cartridge is ignited. Carbon monoxide has a similar density to air and quickly disperses throughout the available space and is not readily adsorbed by soil. DEN-CO-FUME® is widely used to control foxes in natal dens across Australia, but is not yet registered for use in rabbit warrens. Using car exhaust fumes is not an acceptable method of producing carbon monoxide as adequate gas concentrations cannot be achieved and exhaust contaminants cause severe irritation before death. The exhaust gases produced may also be unacceptably hot.[128,123,123]

Diffusion fumigation is preferred over pressure fumigation. Chloropicrin, used for pressure fumigation, is considered to be highly inhumane and its use is not recommended. It causes intense irritation of the respiratory tract and profuse watering of the eyes for a considerable period before death. Additionally, the process of pressure fumigation is slow and cumbersome, and only suitable for small areas.[129]

When fumigating, it is important that rabbits or foxes are inside the burrow and the burrow is sealed to prevent the gas from escaping. Rabbits will have multiple entrances to their warrens and so each of these will need to be located and sealed. The fumigants used are highly toxic to humans and great care should be taken at all times. Furthermore, care should be taken to ensure that the inhabitants of the burrow are, in fact, rabbits as recent research by the Bandicoot Refuge Project has found that quenda take refuge in rabbit burrows to avoid predators.

- Fumigation is the application of a gaseous pesticide; see the information under 'Poisoning' in this topic for more information about the legal requirements associated with pesticide use.
- Standard operating procedures for fumigating fox dens and rabbit warrens are available from the Department of Sustainability, Environment, Water, Population and Communities website.[58]

Shockwaves

Underwater explosions may be used to reduce the number of introduced fish in wetlands.[108] These explosions, caused by very small charges from detonating cords, create shockwaves in the water which kill fish by rupturing their internal swim bladders. Shockwaves were used in combination with other methods to reduce the number of pearl cichlids (*Geophagus brasiliensis*) in the Swan River system in 2006.[109]

This method is relatively inefficient for eradicating introduced fish, and its use should be restricted to environments where other methods are not viable, or where a combination of methods is required for successful eradication.

This method may affect other aquatic fauna in the wetland, including native fish, aquatic mammals, amphibians, and reptiles. Therefore the proposed use of shockwaves is subject to regulation and may trigger the *Environmental Protection Act 1986*.

The use of shockwaves must only be undertaken by a suitably qualified and licensed practitioner.

➤ The removal of freshwater fish species and the use of shockwaves are subject to regulation. For more information, see Table 2 of this topic.

Electrofishing

Electrofishing (also called electric fishing) is a method used to stun fish in the water to allow for easy collection. Electrofishing uses an electric current, delivered into the water by two electrodes (an anode and a cathode), to attract and immobilise fish.[130] There are three types of electrofishers: backpack models, towed barge models and boat mounted models (sometimes called stunboats). Electrofishing is only effective in water shallower than approximately 2.5 metres and in water with a conductivity range of between 10 and 5,000 microsiemens per centimetre (µS/cm); (for comparison, seawater is around 50,000 microsiemens per centimetre).[131]

➤ For more information on conductivity, refer to the topic 'Conditions in wetland waters' in Chapter 2.

When fish encounter the electric current, galvantotaxis occurs, which is an uncontrolled muscular convulsion that makes the fish swim toward the anode. When performed correctly, electrofishing results in no permanent harm to fish, which return to their natural state in as little as two minutes after being stunned. However, great skill is required by the operator to avoid harming fish. Electrofishing can cause harmful effects on fish that are often not externally obvious or fatal, such as spinal injuries and haemorrhages.[132] Because it requires the use of high voltage electricity in and around water, electrofishing equipment is highly specialised and relatively expensive.[130] The risk of injury to both operators and observers is such that an *Australian code of electrofishing practice* has been established. This prescribes the required standards in operator training and certification, equipment and operational practices.

➤ For guidance on electrofishing activities, see the *Australian code of electrofishing practice*.[133] For information on regulations governing the removal of freshwater fish, see Table 2 of this topic.

The annual control program of the goldfish population in the Vasse River involves boat electrofishing. More than 1,200 goldfish have been removed with no native fish deaths recorded in follow-up surveys.

Manipulating habitat and food

Rabbits, foxes and fish can be controlled by manipulating their habitat. Limiting the Australian white ibis' access to unnatural food sources, such as rubbish dumps and rubbish bins, can help ensure that the size of populations dependent on these food sources at wetlands are controlled.

In the case of rabbits and foxes, habitat manipulation refers only to the specific 'habitat' the animals have created, namely their burrows. Rabbit warrens and fox natal dens may be ripped or destroyed with small explosives. This is often used as part of a control program that includes baiting and possibly fumigation. Destroying burrows discourages rabbits and foxes from returning to the area.

➤ Standard operating procedures for rabbit warren destruction by ripping or explosives are available from the Department of Sustainability, Environment, Water, Population and Communities website.[58]

Draining a wetland of water may remove introduced fish. This is an option that must be considered a last resort only and must only be undertaken if legal. It requires an environmental assessment to determine whether it will have a significant environmental impact, taking into account all aspects of the wetland's hydrology, ecology (particularly native aquatic fauna) and chemistry (particularly acid sulfate soils), and may trigger the *Environmental Protection Act 1986*.

While draining a wetland for two to three days may be effective at removing many species of introduced fish, it is likely to kill most if not all native fish and other aquatic fauna within the wetland. There is not a lot of published data on the effectiveness of this method; however anecdotal reports are that a number of attempts at natural wetlands have proven ineffective. It was used to successfully eradicate eastern gambusia (*Gambusia holbrooki*) from the significantly modified wetland, Ilparpa Swamp, in the Northern Territory. After the eastern gambusia were discovered by Waterwatch volunteers, the swamp was pumped dry and was refilled to capacity by rains two weeks later.[66] This method may also be used for carp when they are present in isolated wetlands.

Draining a wetland will not eradicate yabbies. Extreme manual removal (with an excavator) or the use of chemicals may work[134], but these techniques obviously have the potential to create a significant environmental impact.

➤ There are legal requirements regarding the alteration of drainage into or out of wetlands and the alteration of wetland water regimes. For further information, see the topic 'Legislation and policy' in Chapter 5.

case study

Managing nuisance ibis populations

Australian white ibis (*Threskiornis molucca*) are a native species with the potential to form nuisance populations in some areas of WA (Figure 16).

Figure 16. An Australian white ibis (*Threskiornis molucca*). Photo – T Chapman/DEC.

As a scavenging species with a generalised diet, they have adapted well to urban environments.[135] Large numbers of the Australian white ibis can cause damage to wetlands and out-compete native species for food and nesting resources. Booragoon Lake, in southern metropolitan Perth, provides habitat for a large number of waterbirds and is one of the few urban breeding sites for pied cormorants (*Phalacrocorax melanoleucos*). Australian white ibis are also abundant at the lake and are considered nuisance fauna as their large numbers are out-competing pied cormorants for habitat. The nesting habits of the ibis are also damaging wetland vegetation, in particular, the *Melaleuca teretifolia.*[74] The local population of ibis has grown to nuisance size due to an abundant food source in the form of a nearby rubbish dump.[74]

A range of methods have been employed to control nuisance populations of Australian white ibis in Australia. Limiting access to unnatural food sources, such as rubbish tips and bins, is a key measure. Various methods of exclusion from these food sources are available including the use of netting (Figure 17), barriers, ibis-proof litter bins and preventing people from feeding them. These can be combined with complementary measures including limiting water sources and loafing sites, scaring and spotlighting them, shooting them and oiling eggs. There has also been research into a contraceptive pill to be implanted under the skin of captured birds.

➤ For more information on management options for nuisance populations of the Australian white ibis, as well as associated legal requirements, see *Prevention and control of damage by animals in WA: Australian white ibis* Threskiornis molucca.[135]

Figure 17. Ballina landfill in NSW, where netting has been shown to reduce local Australian white ibis populations significantly. Photo – K Patrick/Ecosure.[136]

Manual removal

Manual removal of introduced animals is generally considered to be the most environmentally sensitive method of removal, with few unwanted side effects. As the name suggests, it involves directly removing introduced animals from a wetland. While this can be a labour-intensive process, it may also be the most feasible method available in sensitive environments. It may also be the simplest method of removal in small wetlands or when only a few individuals of the introduced species are present.

One such method of manual removal is the use of dip nets to remove introduced fish from a wetland. This is generally a labour-intensive process and often less efficient than traps (at one site it was found that traps caught five times more fish than hand nets[137]). Care should be taken to ensure that only introduced fish are removed from the wetland and that any native fish that are caught are returned unharmed. Even if it appears that all adults have been removed, repeated fishing attempts may be required, as some individuals may have remained in the form of eggs or juveniles. Populations of warm-water species are smaller[138] and many species are not in reproductive mode in cooler months. However, this advantage is counteracted by the fact that activity and therefore 'catchability' is also diminished. In the dry season water levels are reduced and the concentration of introduced fish is increased. As such, timing should be assessed depending on the habitat and target species. The only known successful eradication of eastern gambusia from a natural aquatic system in WA was achieved by intensive dip netting in a pool in the upper Margaret River catchment that prevented its colonisation into the high conservation value upper reaches when winter flows resumed (S. Beatty pers. comm.). However, dipping is usually far less effective than use of larger nets (such as seine nets) or trapping in larger systems.

All noxious fish species must be destroyed on site. For other species, the Perth Cichlid Society (www.perthcichlid.com.au) offers to accept unwanted fish and provides a list of local fish stores that have agreed to accept unwanted fish. Alternatively, introduced species of fish that are not listed as noxious species may be disposed of humanely by refrigerating them in water until they stop moving, and then moving the container to the freezer overnight. This method has been endorsed by the RSPCA WA Inc.[10]

Experience has shown the most efficient and effective way to remove cane toads is to simply pick them up.[139] Cane toad 'musters' with high levels of community participation have been effective in reducing the number of cane toads present in WA (Figure 18) and was used to successfully eradicate the local population of cane toads in Port Macquarie, New South Wales. The use of deflection fencing may help to make hand collection more efficient.[140] The timing of hand collection is also an important factor as cane toads concentrate around water points during the dry season, making collection easier. Cane toads exude poison from the glands at their shoulders and so care should be taken when handling the toads. Gloves should be worn and care should be taken to avoid the poison getting into eyes, nose or mouth and pets should be removed from the area.

Figure 18. Volunteers counting and sorting cane toads manually collected during the Stop the Toad Foundation's 2009 'Great Toad Muster' in the Kimberley.
Photo – M Andrews.

Once collected, cane toads may be taken to an allocated disposal facility (usually a DEC office or veterinary clinic) or euthanased. It is essential that members of the public are completely certain of the identification of the animal they have captured prior to euthanasing it, as up to two-thirds of suspected cane toads turn out to be harmless native frogs.[8] Cane toad carcasses are still toxic so they should be disposed of carefully—either by burial in a location where it cannot be dug up by other animals, especially pets; or by incineration.

➤ For more information on the control of cane toads, see the DEC website at www.dec.wa.gov.au/canetoads.

Fertility control

Fertility control options may be considered as a means of maintaining low numbers of introduced animals. Immunocontraception is one method of fertility control where the animal's immune system is made to mount an attack against a part of their own reproductive system such that they become infertile. This could be against eggs, sperm or a hormone necessary for successful reproduction.[141]

Trials of immunocontraception, though promising, have shown limited success. This method requires multiple injections to be made to the animals, either directly or by using dart guns. This makes immunocontraception impractical and raises the issue of costs versus benefit. Orally delivered (using baits) immunocontraception is being investigated, particularly for foxes and feral cats. The high uptake rate of 1080 bait by foxes indicates that this form of control has potential.[142]

For immunocontraception to cause rapid population decline, a large proportion of breeding females need to be sterilised.[143] Some animals which have undergone contraception or vaccination have been found to reproduce, which implies that genetic selection for animals which do not respond to the vaccine is possible.[141] These are the issues that must still be resolved before any form of fertility control for introduced species can be used widely in Australia.

How to manage the impacts of introduced animals

Reintroduction: the deliberate release of a species in an area which is part of its natural historical range but in which it no longer occurs

As previously mentioned, introduced animals can have a number of detrimental impacts on wetlands, including:

- predation and competition with native fauna
- spread of diseases, plant pathogens and weeds
- degradation of native vegetation
- soil disturbance
- reduced water quality.

After introduced animals have been 'controlled' (numbers reduced or completely eliminated), a wetland may require additional management to address the impacts of the introduced animals. If a wetland is in good condition, it may be able to recover naturally. If a wetland has been severely degraded and natural recovery is unlikely, active management may be required. In these circumstances, management of both the wetland vegetation and fauna is likely to be required.

If significant vegetation loss or the complete loss of a particular plant species has occurred at a wetland and recruitment is not occurring naturally, revegetation may be considered.

➤ For additional detail on managing wetland vegetation see the topic 'Managing wetland vegetation' in Chapter 3.

If fauna have disappeared from a wetland because of the impacts of introduced animals and they do not return to the wetland after the introduced animals have been removed, **reintroduction** of the native fauna may be possible. Reintroductions should only be attempted after all threats (not just introduced animals) to the animal in question have been removed from the wetland and when it is unlikely that these threats will return.

Reintroduction programs are often stressful and dangerous to the fauna being moved, may result in the inadvertent spread of harmful diseases and pathogens, and may result in the loss of genetic integrity of an existing population. As such, reintroduction is an option that should only be considered in collaboration with the relevant authorities, typically DEC and/or the Department of Fisheries. The reintroduction, relocation (translocation) and introduction of animals into new areas are subject to regulations administered by these departments (see Table 2 for more information).

case study

Restocking native fish in masons gardens Lake, Dalkeith

A proactive partnership between a school and local and state government has achieved a significant reduction in the numbers of introduced fish in Masons Gardens Lake in Dalkeith.

In 2009 enthusiastic representatives from the City of Nedlands, Department of Fisheries and Shenton College developed an innovative project to remove introduced fish and address nuisance mosquito problems and algal blooms in the wetland, while providing the students of Shenton College with a living classroom in which to develop a range of skills and gain hands-on experience (Figure 19).

As part of an investigation into the ecology of the lake, seventy students used fish traps, scoop nets and drop nets to conduct a baseline survey of the fish population. During this survey they found the introduced eastern gambusia (*Gambusia holbrooki*) (Figure 20) co-inhabiting the wetland with native pygmy perch (*Edelia vittata*) and Swan River goby (*Pseudogobius olorum*) that were stocked by Murdoch University's Freshwater Fish Group in 2004 for the City of Nedlands.

Based on the information gained from the baseline surveys, the project partners opted to remove the eastern gambusia using traps because traps have a relatively low impact on the native fish population and wetland and are safe for use by students, unlike poison, shockwaves and electrofishing. They decided to manage the excess mosquitoes and algae in the wetland using biological remediation techniques rather than using pesticides and herbicides, which at best address the symptoms rather than the causes, and often create a range of other problems in wetlands.

The students conducted an intensive trapping regime over a three-month period using box-mesh traps to remove as many eastern gambusia as possible. It is estimated that the students removed 80 per cent of the eastern gambusia from the wetland, and at the end of trapping the ratio of eastern gambusia to native fish had fallen from 156:1 to 30:1. In comparing the efficiency of methods of capturing eastern gambusia, students found that traps caught five times more fish than hand nets. The students were able to raise awareness in the local community about the project and their findings via the local paper and a student podcast.

It is anticipated that the reduction in eastern gambusia will enable the native fish population

Figure 19. Dr Craig Lawrence from the Department of Fisheries with Shenton College students and (background) City of Nedlands staff Rob Burton and Vicki Shannon, at Masons Gardens Lake. Photo – W. Russell/courtesy of the Community Newspaper Group.

case study

Figure 20. The introduced eastern gambusia, *Gambusia holbrooki*. Photo – C Lawrence/Department of Fisheries.

in the wetland to increase. To assist the recovery of the native fish population in Masons Gardens Lake, species including pygmy perch (*Edelia vittata*), western minnow (*Galaxias occidentalis*) and smooth marron (*Cherax cainii*) were stocked into the wetland using carefully selected genetic stocks bred at the Aquaculture and Native Fish Breeding Laboratory at The University of Western Australia. These species were chosen on the basis that they are endemic to the catchment and could be supplied from the laboratory. The breeding program was an extensive and highly technical process designed to ensure that the genetic vigour of the fish was maintained. Following breeding, the individuals were carefully acclimatised to temperature and water quality of Masons Gardens Lake, and the conditions in which they were transported to the wetland (such as oxygen levels in the water) were carefully managed to maximise their survival rate in the wetland. It is proposed that Shenton College students continue ongoing monitoring of the recovery of the native fish population and trapping of introduced species to ensure their rehabilitation efforts have a long-term effect in their adopted wetland. As the eastern gambusia is a prolific breeder, it is very important that ongoing control continues.

It is hoped that by increasing the number of native fish in the wetland, nuisance mosquito problems can also be reduced, because native fish consume mosquitoes and their larvae. It is also hoped that the native fish species will consume algae, thereby contributing to the reduction of algal blooms; this is currently being evaluated.

Furthermore, the reduction in the numbers of eastern gambusia should indirectly lead to a reduction in algal blooms. This is because eastern gambusia prey on water fleas (*Daphnia carinata*), an aquatic macroinvertebrate that feeds primarily on algae. The loss of water fleas from the wetland can lead to algal blooms, which in turn provides an abundant food source for mosquitoes and midges, which can stimulate population booms.

In these ways, it is hoped that the biological remediation program improves the condition of the wetland while reducing the need to resort to the application of pesticides and herbicides in the wetland in the future.

This project, which is improving the habitat of the native fish population and the condition of the wetland using low-impact management techniques with the participation of local students, is an inspiring model for future wetland management initiatives.

Note: this case study has been compiled from information in a report by Shenton College students[137] and personal communication with Dr Craig Lawrence. The methods employed in this project were undertaken in compliance with regulations governing the management of freshwater fish and crustaceans; see Table 2 for more information.

Sources of more information on managing nuisance and introduced animals

General

Department of Agriculture and Food Western Australia
www.agric.wa.gov.au
Information on introduced animals considered pests to agriculture and the environment, including a list of declared pest species and information on management options, is provided on the Department of Agriculture and Food website.[144]

Feral.org.au
www.feral.org.au
Website and database containing information on vertebrate pest animal species in Australia and New Zealand.

Invasive Animal Cooperative Research Centre
www.invasiveanimals.com
Australia's largest integrated invasive animal research program.

Codes of conduct and standard operating procedures

Department of Local Government and Regional Development (2003) *Code of practice for the capture and marketing of feral animals in Western Australia*[57]

Various codes of conduct and standard operating procedures for the humane capture, handling or destruction of introduced animals in Australia published by the Department of Sustainability, Environment, Water, Population and Communities[58]

DEC's Standard Operating Procedures for monitoring (which includes trapping that may be extended to control operations) may be found on the DEC website[59]

Department of Health (2009). *A guide to the management of pesticides in local government pest control programs in Western Australia*[145]

Species-specific

Australian white ibis

Department of Environment and Conservation (2007). *Prevention and control of damage by animals in WA: Australian white ibis* Threskiornis molucca[135]

Camels, feral

Department of Agriculture and Food (2000). Farmnote No. 122/2000 [Reviewed 2008] *Feral camel*[146]

Cane toads

Cane Toads in Oz
www.canetoadsinoz.com

Department of Environment and Conservation (2009). *Cane Toad Strategy for Western Australia 2009–2019*[139]

Department of Environment and Conservation
www.dec.wa.gov.au/canetoads

Kimberley Toad Busters
www.canetoads.com.au

Northern Australian Frogs Database System
www.frogwatch.org.au

Stop the Toad Foundation
www.stopthetoad.org.au

Cats, feral

NSW Department of Primary Industries. *Model code of practice for the humane control of feral cats*[75]

Donkeys, feral

Department of Agriculture (2000). Farmnote No. 121/2000 [Reviewed 2007] *Feral donkey*[147]

Fish and crayfish, introduced

Department of Fisheries (2009) *Aquatic invaders – Introduced species are a threat to our aquatic biodiversity*[108]

Department of Fisheries (2010) *Freshwater fish distribution in Western Australia database*[148]

Morgan, DL, Beatty, SJ, Klunziger, MW, Allen, MG, Burnham, QF (2011), *A field guide to freshwater fishes, crayfishes and mussels of south-western Australia*, SERCUL and Murdoch University, Perth, Western Australia.

Morgan, Gill, Maddern and Beatty (2004) *Distribution and impacts of introduced freshwater fishes in Western Australia*[149]

Corfield et al. (2008) *Review of the impacts of introduced ornamental fish species that have established wild populations in Australia*[150]

Foxes

Department of Agriculture (2001). Farmnote 91/2001 [reviewed July 2005] *Options for fox control*[151]

NSW Department of Primary Industries. *Model code of practice for the humane control of foxes*[152]

Goats, feral

Department of Agriculture (2000). Farmnote No. 83/2000 [Reviewed 2007] *Feral goat*[153]

NSW Department of Primary Industries. *Model code of practice for the humane control of feral goats*[154]

Horses, feral

NSW Department of Primary Industries. *Model code of practice for the humane control of feral horses*[155]

Kangaroos

Department of Environment and Conservation (2007). *Fauna note No. 29: Western Grey Kangaroo*[156]

Department of Environment and Conservation (2007). *Fauna note No. 30: Western Grey Kangaroo management plan*[157]

Livestock, feral

Standing Committee on Agriculture and Agricultural Health Committee (1995), *Feral livestock animals – destruction or capture, handling and marketing*[79]

Pigs, feral

Department of Agriculture and Food (2003). Farmnote No. 36/2003 *Feral pig control by trapping*[158]

NSW Department of Primary Industries. *Model code of practice for the humane control of feral pigs*[159]

Rabbits, feral

Department of Agriculture (2001). Farmnote 89/2001 [reviewed October 2007] *Options for rabbit control*[160]

NSW Department of Primary Industries. *Model code of practice for the humane control of rabbits*[128]

Turtles, introduced

Department of Agriculture and Food (2009). *Red-eared slider: Animal pest alert no. 6/2009*[9]

Monitoring

Department of Agriculture and Food (2010) *Ecologically significant invasive species: A monitoring framework for natural resource management groups in Western Australia*[55]

Reporting introduced animal sightings

Pest and Disease Information Service: 1800 084 881

FISHWATCH service, Department of Fisheries: 1800 815 507

Glossary

Aquatic invertebrates: those animals without a backbone (such as insects, worms, snails, molluscs, water mites and larger crustacean such as shrimps and crayfish) that live in or on water for at least one phase in their life cycle

Amphibians: the class of animals to which frogs, toads and salamanders belong. They live on land but develop by a larval phase (tadpoles) in water.

Biodiversity: a contraction of the words 'biological' and 'diversity', encompassing the whole variety of life forms—the different plants, animals, fungi and microorganisms—the genes they contain, and the ecosystems they form

Biological control: the control of an introduced plant or animals by the introduction of a natural predator or pathogen, usually bacteria, viruses or insects, or by biological products such as hormones

Browsing: feeding on leaves, twigs or bark from non-herbaceous (woody) plants, such as trees and shrubs

Endemic: naturally occurring only in a restricted geographic area

Erosion: the gradual wearing away and movement of land surface materials (especially rocks, sediments, and soils) by the action of water, wind, or a glacier

Eutrophication: the nutrient enrichment of a water body, which can trigger prolific growth of plant material (phytoplankton, macrophytes or both). May occur naturally over geologic time or may be human-induced

Feral animals: introduced animals that have escaped, or have been released, from domestication and returned, partly or wholly, to their wild state

Grazing: feeding on grasses and other low-growing herbaceous vegetation

Habitat: an area or environment where conditions are suitable for the survival of an organism, taxon or community

Herbivores: animals that chiefly eat plants

Hybrids: the results of interbreeding between two animals or plants of different species

Introduced animals: species of animals that have been intentionally or unintentionally brought into a region where they did not historically occur, usually facilitated by humans

Livestock: introduced domestic ungulate (or hoofed) animals

Nuisance fauna: native animals that naturally occur at a site, but which have reached a population size that is causing harm to the environment or humans

Nocturnal: primarily active during the night

Omnivorous: feeding on both plants and animals

Pesticide: any chemical or biological agent intended to kill animals or plants

Piscicide: a chemical substance which is poisonous to fish

Propagule: any part of a plant from which a new plant can grow, including seeds, bulbs and rootstocks

Pugging: depressions, hoof prints or 'pug' marks made in wet soil by trampling animals

Reintroduction: the deliberate release of a species in an area which is part of its natural historical range but in which it no longer occurs

Sedimentation: the process by which soil particles (sand, clay, silt, pebbles and organic materials) suspended in water are deposited or settle to the bottom of a water column

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

Turbid: the cloudy appearance of water due to suspended material

Turbidity: the extent to which light is scattered and reflected by particles suspended or dissolved in the water column

Personal communications

Name	Date	Position	Organisation
Bill Bardsley	18/06/2010	Senior Biosecurity Officer	Department of Fisheries, Western Australia
Cara Francis	23/07/2009	Technical Officer	Department of Environment and Conservation, Western Australia

Dr Craig Lawrence	04/2010	Principal Research Scientist; Adjunct Associate Professor	Department of Fisheries, Western Australia; The University of Western Australia
Mark Muir	27/07/2010	Chairman	Lake Muir Denbarker Community Feral Pig Eradication Group
Dr Stephen Beatty	08/05/2012	Research Fellow	Murdoch University

References

1. Burbidge, AA and McKenzie, NL (1989). 'Patterns in the modern decline of Western Australia's vertebrate fauna: causes and conservation implications', *Biological Conservation*, vol. 50, pp. 143–198.
2. Braysher, M (1993). *Managing vertebrate pests: principles and strategies*. Australian Government Publishing Service, Canberra, ACT.
3. Rolls, E (1969). *They all ran wild*. Angus & Robertson Publishers.
4. The Sunday Times '*Cane toads surf the Ord*'. T Paddenburg, News Limited, Perth, Western Australia.
5. Allen, GR, Midgley, SH, and Allen, M (2002). *Field guide to the freshwater fishes of Australia*. Western Australian Museum.
6. The Post (2010). '*What strange beast lurks in the lake?*'. Gorman, L. The Post, Perth, Western Australia.
7. Michael Morcombe (2003). *Field guide to Australian birds*, Revised edition. Steve Parish Publishing Pty Ltd.
8. Department of Environment and Conservation *Is it a cane toad?* Department of Environment and Conservation, Perth, Western Australia. www.dec.wa.gov.au/index2.php?option=com_docman&task=doc_view&gid=3374&Itemid=99999999.
9. Department of Agriculture and Food (2009). *Red-eared slider: Animal pest alert no. 6/2009*. Department of Agriculture and Food, Perth, Western Australia. www.agric.wa.gov.au/objtwr/imported_assets/content/pw/vp/toad/red-earedslideralert.pdf.
10. Department of Fisheries (2006). *Aquatic invaders: Introduced species are a threat to our inland waterways!* Department of Fisheries, Perth, Western Australia.
11. Department of Fisheries (2004). *Identifying freshwater crayfish in the south west of Western Australia*. Prepared by B Molony & J Dunn, Department of Fisheries, Perth, Western Australia. www.fish.wa.gov.au/docs/pub/IdCrayfish/FreshCrayFishId2004.pdf.
12. Department of Agriculture and Food (2010). *Rusa deer: Animal pest alert*. Department of Agriculture and Food, Perth, Western Australia. www.agric.wa.gov.au/objtwr/imported_assets/content/pw/vp/animalpestalertrusadeer.pdf.
13. Triggs, B (2009). *Tracks, scats and other traces: a field guide to Australian mammals*. Oxford University Press, Melbourne, Victoria.
14. Department of Conservation and Land Management (2001). *Wildlife Note No. 10: Sand pads – using tracks to monitor fauna*. P Mawson and P Orell, Department of Conservation and Land Management, Perth, Western Australia.
15. Environmental Protection Authority (2007). *State of the Environment Report: Western Australia 2007*. Department of Environment and Conservation, Perth, Western Australia. www.soe.wa.gov.au.
16. Pimentel, D, McNair, S, Janecka, J, Wightman, J, Simmonds, C, O'Connell, C, Wong, E, Russel, L, Zern, J, Aquino, T, and Tsomondo, T (2001). 'Economic and environmental threats of alien plant, animal, and microbe invasions', *Agriculture, Ecosystems & Environment*, vol. 84, pp. 8–20.
17. Edwards, GP, Pople, AR, Saalfeld, K, and Caley, P (2004). 'Introduced mammals in Australian rangelands: future threats and the role of monitoring programmes in management strategies', *Austral Ecology*, vol. 29, pp. 40–50.

18. McLeod, R (2004). *Counting the cost: impact of invasive animals in Australia 2004*. Cooperative Research Centre for Pest Animal Control, Canberra, ACT.
19. Saunders, G, Coman, BJ, Kinnear, JE, and Braysher, M (1995). *Managing vertebrate pests: foxes*. Australian Government Publishing Service, Canberra, ACT.
20. Short, J and Smith, AP (1994). 'Mammal decline and recovery in Australia', *Journal of Mammalogy*, vol. 75, issue 2, pp. 288–297.
21. Martensz, PN (1971). 'Observations of the food of the fox, *Vulpes vulpes* (L.) in an arid environment', *Wildlife Research*, vol. 16, issue 1, pp. 75–76.
22. Coman, BJ (1979). 'The diet of red foxes, *Vulpes vulpes* L., in Victoria', *Australian Journal of Zoology*, vol. 21, issue 3, pp. 39 – 401.
23. Croft, JD and Hone, LJ (1978). 'The stomach contents of foxes, *Vulpes vulpes*, collected in New South Wales', *Australian Wildlife Research*, vol. 5, issue 1, pp. 85–92.
24. Liberg, O (1984). 'Food habits and prey impact by feral and house-based domestic cats in a rural area in southern Sweden', *Journal of Mammalogy*, vol. 65, pp. 424–434.
25. Choquenot, D, McIlroy, JC, and Korn, TJ (2009). *Managing vertebrate pests: feral pigs*. Bureau of Resource Sciences, Australian Government Publishing Service, Canberra, ACT.
26. Courchamp, F, Langlais, M, and Sugihara, G (1999). 'Cats protecting birds: Modelling the mesopredator release effect', *Journal of Animal Ecology*, vol. 68, issue 2, pp. 282–292.
27. Towns, D, Atkinson, I, and Daugherty, C (2006). 'Have the harmful effects of introduced rats on islands been exaggerated?', *Biological Invasions*, vol. 8, issue 4, pp. 863–891.
28. Bradsell, P, Prince, J, Kuchling, G, and Knott, B (2002). 'Aggressive interactions between freshwater turtle, *Chelodina oblonga*, hatchlings and freshwater crayfish, *Cherax* spp.: implications for the conservation of the critically endangered western swamp turtle, *Pseudemydura umbrina*.', *Wildlife Research*, vol. 29, pp. 295–301.
29. Department of Environment, Water, Heritage and the Arts (2005). *The biological effects, including lethal toxic ingestion, caused by Cane Toads (Bufo marinus)*. Department of the Environment, Water, Heritage and the Arts, Canberra, ACT.
30. Lynas, J, Storey, AW, and Knott, B (2007). 'Introduction and spread of crayfish (Parastacidae) in Western Australia and their potential to displace native species', in Gherardi, F (Ed.), *Biological invaders in inland waters: profiles, distribution and threats*. Springer, Netherlands.
31. Lynas, J, Storey, AW, Armstrong, K, Prince, J, and Knott, B (2006). 'Invasion by the exotic crayfish, *Cherax destructor* Clark (Parastacidae) into habitats of local crayfish near Perth, Western Australia', *Freshwater Crayfish*, vol. 15, pp. 176–188.
32. Southgate, RI (1990). 'Habitats and diet of the Greater Bilby *Macrotis lagotis* Reid (Marsupalia:Peramelidae)', pp. 303–309, in Seebeck, JH, Brown, PR, Wallis, RI, and Kemper, CM (Eds), *Bandicoots and bilbies*. Surrey Beatty & Sons, Sydney, New South Wales.
33. Laurance, WF and Harrington, GN (1997). 'Ecological associations of feeding sites of feral pigs in the Queensland wet tropics', *Wildlife Research*, vol. 24, pp. 579–590.
34. Department for Environment and Heritage (2005). T*hreat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs*. Department of Environment and Heritage, Canberra, ACT.
35. The West Australian (2008). '*Hunt on as aggressive turtles stalk Perth lakes*'. A Pownall. West Australian Newspapers Holdings Limited, Perth, Western Australia.
36. Romanowski, N (2010). *Wetland habitats: A practical guide to restoration and management*. CSIRO, Victoria.
37. The West Australian (2009). '*Turtle that threatens native species found in Perth*'. A Lucev & J Rickard. West Australian Newspapers Holdings Limited, Perth, Western Australia.
38. Holland, GN (2003). 'Ocular toxoplasmosis: A global reassessment. Part I: Epidemiology and course of disease', *American Journal of Ophthamology*, vol. 136, issue 6, pp. 973–988.

39. Attwood, HD, Woolley, PA, and Rickard, MD (1975). 'Toxoplasmosis in dasyurid marsupials', *Journal of Wildlife Diseases*, vol. 11, issue 4, pp. 543–551.
40. Obendorf, DL and Munday, BL (1990). 'Toxoplasmosis in wild eastern barred bandicoots, *Perameles gunnii*', pp. 193–197, in Seebeck, JH, Brown, PR, Wallis, RL, and Kemper, CL (Eds), *Bandicoots and bilbies*. Surrey Beatty & Sons Pty Ltd, Sydney, NSW.
41. Coman, BJ (1973). 'Helminths parasites of the fox (*Vulpes vulpes*) in Victoria', *Australian Veterinary Journal*, vol. 49, pp. 378–384.
42. Department of the Environment and Heritage *Feral horse (Equus caballus) and feral donkey (Equus asinus)*. Department of the Environment and Heritage, http://www.environment.gov.au/biodiversity/invasive/publications/pubs/feral-horse.pdf.
43. Department of Environment Climate Change and Water (2009). *Predation and hybridisation by feral dogs (Canis lupus familiaris): key threatening process listing*. www.environment.nsw.gov.au/determinations/feraldogsFD.htm.
44. Braithwaite, LW and Miller, B (1975). 'The mallard, *Anas platyrhynchos*, and mallard-black duck, *Anas superciliosa rogersi*, hybridisation', *Australian Wildlife Research*, vol. 2, pp. 47–61.
45. Kliejunas, JT and Ko, WH (1976). 'Dispersal of *Phytopthora cinnamomi* on the island of Hawaii', *Phytopathology*, vol. 66, pp. 457– 460.
46. Brown, BN (1976). '*Phytophthora cinnamoni* associated with patch death in tropical rainforests in Queensland', *Australian Plant Pathology Society Newsletter*, vol. 5, pp. 1–4.
47. Li, A (2009). 'Dissemination of *Phytophthora cinnamomi* by feral pigs'22/6/2009.
48. The West Australian (2010). '*Aphids blamed for killing river plant*'. J. Hammond. West Australian Newspapers Holdings Limited, Perth, Western Australia.
49. Boulton, AJ and Brock, MA (1999). *Australian freshwater ecology: Processes and management*. Gleneagles Publishing, Glen Osmond, South Australia.
50. Storey, AW (2005). *Waterways management in the east Kimberley rangelands: a perspective from Kachana Station*. www.kachana.com//projects_research/or_a_storey_waterways.php.
51. Invasive Animals CRC (2009). *Invasive animals: fish*. www.invasiveanimals.com/invasive-animals/fish/index.html.
52. Kolmakov, VI and Gladyshev, MI (2003). 'Growth and potential photosynthesis of cyanobacteria are stimulated by viable gut passage in crucian carp', *Aquatic Ecology*, vol. 37, issue 3, pp. 237–242.
53. Morgan, DL and Beatty, SJ (2007). 'Feral Goldfish (*Carassius auratus*) in Western Australia: A case study from the Vasse River', *Journal of the Royal Society of Western Australia*, vol. 90, pp. 151–156.
54. The West Australian (2010). '*First signs of victory in war on bush pests*'. S Quinton, West Australian Newspapers Holdings Limited, Perth, Western Australia.
55. Department of Agriculture and Food (2010). *Ecologically significant invasive species: A monitoring framework for natural resource management groups in Western Australia*. Prepared by JW Milliano, A Woolnough, A Reeves, D Shepherd, Western Australian Agriculture Authority, Perth, Western Australia.
56. Standing Committee on Agriculture Fisheries and Forestry (2005). *Taking control: a national approach to pest animals*. House of Representatives, Standing Committee on Agriculture, Fisheries and Forestry, Canberra, ACT.
57. Department of Local Government and Regional Development and Department of Agriculture (2003). *Code of practice for the capture and marketing of feral animals in Western Australia*. Department of Local Government and Regional Development, Perth, Western Australia. www.dlg.wa.gov.au/App/OpenFile.ashx?Mode=446E376867 49376A356D684D2B6E6D6D4D6E555273773D3D&ContentID=773472785459784B 4C656B3D.
58. Department of the Environment Water Heritage and the Arts (2010). *Development of a model code of practice and standard operating procedures for the humane capture, handling or destruction of feral animals in Australia*. Department of the Environment, Water, Heritage and the Arts, www.environment.gov.au/biodiversity/invasive/publications/humane-control.html.

59. Department of Environment and Conservation (2010). *Standard operating procedures*. Government of Western Australia, Perth, Western Australia. www.dec.wa.gov.au/content/view/5389/2237/.
60. Department of Environment and Conservation (2010). *Fauna licensing*. Department of Environment and Conservation, Perth, Western Australia. www.dec.wa.gov.au/content/view/864/1991/.
61. Western Australian Police (2010). *Firearms*. Western Australian Police, Perth, Western Australia. www.police.wa.gov.au/Ourservices/Firearms/tabid/1616/Default.aspx.
62. Department of Agriculture and Food (2007). *Landholder information for the safe use and management of 1080*. State of Western Australia, Perth, Western Australia. www.agric.wa.gov.au/objtwr/imported_assets/content/pw/vp/toxin/1080landholderinformationpackage.pdf.
63. NSW National Parks and Wildlife Service (2003). *NSW threat abatement plan. Predation by Gambusia holbrooki – the plague minnow*. NSW National Parks and Wildlife Service, Hurstville NSW. www.environment.nsw.gov.au/resources/nature/ThreatAbatementPlanPlaqueMinnow.pdf.
64. Department of Primary Industries (2005). *Aquatic invaders, exotic pest fish: An education module for upper primary and lower seconday school*. The State of Queensland, www2.dpi.qld.gov.au/extra/aquaticinvaders/default.html.
65. United Nations Environment Programme *Manual on compliance with and enforcement of multilateral environmental agreements: public environmental awareness and education*. www.unep.org/dec/onlinemanual/Enforcement/InstitutionalFrameworks/PublicAwarenessEducation/tabid/99/Default.aspx?page=2.
66. Waterwatch Australia (2005). *Environmental action through community monitoring: case studies*. Department of Environment and Heritage, Canberra, ACT. www.waterwatch.org.au/publications/communitymonitoringstudies.html.
67. Agriculture Protection Board (2009). *Declared animals*. Agriculture Protection Board, Perth, Western Australia. www.agric.wa.gov.au/objtwr/imported_assets/content/pw/vp/declared_animals.pdf.
68. Department of Fisheries (2010). *Fish species restricted for importation into Western Australia – noxious fish*. Department of Fisheries, Perth, Western Australia. www.fish.wa.gov.au/docs/pub/RestrictedFish/noxious-list.php?0505.
69. Department of Local Government (2010). *Proposed domestic cat control legislation*. Department of Local Government, Perth, Western Australia. www.dlg.wa.gov.au/Content/Legislation/ProposedCatAct.aspx.
70. City of Joondalup (2010). *Cats in the City of Joondalup*. www.joondalup.wa.gov.au/Live/AnimalsInTheCity/Cats.aspx.
71. City of Stirling (2010). *Responsible cat ownership*. City of Stirling, Stirling, Western Australia. www.stirling.wa.gov.au/NR/rdonlyres/F960EBD7-8CC8-4065-B75F-55F8488524F4/1221/Cat_DL2007.pdf.
72. Department of Environment, Water, Heritage and the Arts (2009). *Catalogue of fence designs*. Department of the Environment, Water, Heritage and the Arts, www.environment.gov.au/biodiversity/invasive/publications/pubs/catalogue.pdf.
73. Bertram, J, Williams, O, Gill, B, Coventry, J, and Seidel, P (2006). *Camel control using altenative fencing*. Northern Territory Government, Alice Springs. www.nt.gov.au/d/Content/File/p/Anim_Man/224.pdf.
74. Fox, E and Mac Shane, M (2004). *Booragoon Lake Reserve Management Plan*. Bennet Brook Environmental Service for the City of Melville, Perth, Western Australia. www.melvillecity.com.au/environment/environmental-management-plans/booragoon-lake-management-plan/booragoon_management_plan.pdf.
75. NSW Department of Primary Industries. *Model code of practice for the humane control of feral cats*. Prepared by T Sharp & G Saunders, NSW Department of Primary Industries www.environment.gov.au/biodiversity/invasive/publications/pubs/cop-feral-cats.pdf.
76. Tolga Bat Hospital (2008). *Wildlife friendly fencing guidelines*. Tolga Bat Hospital www.wildlifefriendlyfencing.com/glines.htm.

77. Department of Environment and Conservation (2007). *Fauna Note No.32: Fencing and gates to reduce kangaroo damage*. Department of Environment and Conservation, Perth, Western Australia. www.dec.wa.gov.au/index2.php?option=com_docman&task=doc_view&gid=1221&Itemid=841.
78. NSW Department of Primary Industries (2004). *Methods of euthanasia*. Prepared by T Sharp & G Saunders, NSW Department of Primary Industries, NSW. www.environment.gov.au/biodiversity/invasive/publications/pubs/gen001-methods-euthanasia.pdf.
79. Standing Committee on Agriculture and Agricultural Health Committee (1995). Model code of practice for the welfare of animals: *Feral livestock animals - destruction or capture, handling and marketing*. Commonwealth of Australia, Canberra. www.publish.csiro.au/Books/download.cfm?ID=370.
80. Department of Environment and Conservation (2009). *Standard operating procedure No. 9.2: Cage traps for the live capture of terrestrial vertebrates*. Prepared by C Freegard & V Richter, Department of Environment and Conservation, Perth, Western Australia. www.dec.wa.gov.au/content/view/5389/2239/.
81. Department of Agriculture (2003). Farmnote No. 36/2003: *Feral pig control by trapping*. Prepared by D Lund, T Knight, G Martin, State of Western Australia, Perth, Western Australia.
82. Department of Agriculture and Food (2005). *Farmnote 110/2000: Feral Pig*. Department of Agriculture and Food, Perth, Western Australia. www.agric.wa.gov.au/content/pw/vp/fer/f11000.pdf.
83. Lake Muir/Denbarker Community Feral Pig Eradication Group Committee (2009). *Community action to eradicate feral pigs*. Lake Muir/Denbarker Community Feral Pig Eradication Group Committee, Rocky Gully, Western Australia. www.feralpig.southcoastwa.org.au/reports/fpegip.pdf.
84. Higgs, T, Howe, M, and Lyons, M (2008). *The Lake Muir and Denbarker Community Feral Pig Eradication Group; a cooperative project on feral pig control on the South Coast of Western Australia: Bi-annual report 2007 and 2008*. Department of Agriculture and Food and Green Skills Inc, www.feralpig.southcoastwa.org.au/index.html.
85. Department of Environment and Conservation (2009). *Standard operating procedure No. 9.1: Elliot traps for live capture of terrestrial vertebrates*. Prepared by C Freegard & C Richter, Department of Environment and Conservation, Perth, Western Australia. www.dec.wa.gov.au/content/view/5389/2239/.
86. NSW Department of Primary Industries (2004). *Trapping of feral cats using padded-jaw traps*. Prepared by T Sharp & G Saunders, the Department of the Environment and Heritage, Canberra, ACT. www.environment.gov.au/biodiversity/invasive/publications/humane-control.html.
87. NSW Department of Primary Industries (2004). *Trapping of rabbits using padded-jaw traps.* Prepared by T Sharp & G Saunders, the Department of the Environment and Heritage, Canberra, ACT. www.environment.gov.au/biodiversity/invasive/publications/humane-control.html.
88. NSW Department of Primary Industries (2004). *Trapping of foxes using padded-jaw traps*. Prepared by T Sharp & G Saunders, the Department of the Environment and Heritage, Canberra, ACT. www.environment.gov.au/biodiversity/invasive/publications/humane-control.html.
89. NSW Department of Primary Industries (2004). *Trapping of wild dogs using padded-jaw traps*. Prepared by T Sharp & G Saunders, the Department of the Environment and Heritage, Canberra, ACT. www.environment.gov.au/biodiversity/invasive/publications/humane-control.html.
90. Thwaites, LA, Smith, BB, Decelis, M, Fleer, D, and Conallin, A (2010). 'A novel push trap element to manage carp (*Cyprinus carpio* L.): a laboratory trial', *Marine & Freshwater Research*, vol. 61, issue 4, pp. 42–48.
91. Department of Fisheries (2007). *Media release: Minister allows fish traps to reduce feral redclaw population*. Department of Fisheries, Perth, Western Australia. www.fish.wa.gov.au/docs/media/index.php?0000&mr=497.

92. Kuchling (2003). 'A new underwater trap for catching turtles', *Herpetological Review*, vol. 34, issue 2, pp. 126–128.
93. Gamble, T (2006). 'The relative efficiency of basking and hoop traps for painted turtles (*Chrysemys picta*)', *Herpetological Review*, vol. 37, issue 3, pp. 308–312.
94. Griffiths, RA (1985). 'A simple funnel trap for studying newt populations and an evaluation of trap behaviour in smooth and palmate newts, *Triturus vulgaris* and *T. helveticus*', *Journal of Her*, vol. 1, pp. 5–10.
95. Adams, MJ, Richter, KO, and Leonard, WP (1997). 'Surveying and monitoring amphibians using aquatic funnel traps', pp. 47–54, in Olson, DH, Leonard, WP, and Bury, RB (Eds), *Sampling amphibians in lentic habitats (Northwest Fauna 4)*. Society for Northwestern Vertebrate Biology, Olympia, Washington.
96. Calef, GW (1973). 'Natural mortality of tadpoles in a population of *Rana aurora*', *Ecology*, vol. 54, pp. 741–758.
97. Richter, KO (1995). 'A simple aquatic funnel trap and its application to wetland amphibian monitoring', *Herpetological Review*, vol. 26, pp. 90–91.
98. Smith, GR and Rettig, JE (1996). 'Effectiveness of aquatic funnel traps for sampling amphibian larvae', *Herpetological Review*, vol. 27, pp. 190–191.
99. Pople, T and Grigg, G (1999). *Commercial harvesting of kangaroos in Australia*. Environment Australia, Canberra, ACT.
100. Department of Conservation and Land Management and Conservation Commission of Western Australia (2005). *Thomsons Lake Nature Reserve Management Plan 2005*. Management Plan No. 54, Conservation Commission of Western Australia, Perth, Western Australia. www.dec.wa.gov.au/component/option,com_docman/task,doc_download/gid,3254/Itemid,1.
101. Department of Conservation and Land Management (2006). *Media release: 'Kangaroo management for Thomsons Lake Nature Reserve'*. Department of Environment and Conservation, Perth, Western Australia.
102. Douglas, A (2009). 'The chemical control of mosquitoes', pp. 101–115 *Mosquito management manual*. Department of Health, Perth, Western Australia.
103. Prince, M (1998). *ECHO technical note: Jicama*. ECHO, North Fort Myers, Florida.
104. Ling, N (2003). 'Rotenone – a review of its toxicity and use for fisheries management', *Science for Conservation*, vol. 211.
105. Gehrke, PC (2003). 'Preliminary assessment of oral rotenone baits for carp control in NSW' *Managing invasive freshwater fish in New Zealand*. Proceedings of a workshop hosted by the Department of Conservation, Hamilton, 10/5/2001.
106. Finlayson, B, Schnick, R, Skaar, D, Anderson, J, Demong, L, Duffield, D, Horton, W, and Steinkjer, J (2010). *Planning and standard operating procedures for the use of rotenone in fish management*. American Fisheries Society, USA.
107. Department of Primary Industries (2009). *Eradication of one-spot livebearer, Phalloceros caudimaculatus, at Long Reef Golf Course: a post-eradication report.*, New South Wales. www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/287051/Eradication-of-one-spot-livebearer.pdf.
108. Department of Fisheries (2009). *Aquatic invaders: introduced species are a threat to our biodiversity*. www.fish.wa.gov.au/docs/pub/IMPFreshwater/index.php?0506.
109. Department of Fisheries (2006). *Control program for pearl cichlids in Kiara and Lockridge*. Department of Fisheries, www.fish.wa.gov.au/docs/pub/IMPFeralFish/index.php?0506.
110. Department of Fisheries (2009). *Unwanted fish found in Swan River*. www.fish.wa.gov.au/docs/media/index.php?0000&mr=616.
111. King, DR, Oliver, AJ, and Mead, RJ (1978). 'The adaptation of some Western Australian mammals to food plants containing fluoroacetate', *Australian Journal of Zoology*, vol. 26, pp. 699–712.
112. Oliver, AJ, King, DR, and Mead, RJ (1979). 'Fluoroacetate tolerance, a genetic marker in some Australian mammals', *Australian Journal of Zoology*, vol. 27, pp. 363–372.
113. Department of Environment, Water. Heritage and the Arts (2008). *Threat abatement plan for predation by the European red fox*. Department of Environment, Water, Heritage and the Arts, Canberra, ACT.

114. Allen, LR, Fleming, PJS, Thompson, JA, and Strong, K (1989). 'Effect of presentation on the attractiveness and palatability to wild dogs and other wildlife of two unpoisoned wild-dog bait types', *Australian Wildlife Research*, vol. 16, pp. 593–598.
115. Glen, AS and Dickman, CR (2003). 'Effects of bait-station design on the uptake of baits by non-target animals during control programmes for foxes and wild dogs', *Wildlife Research*, vol. 30, pp. 147–149.
116. Belcher, CA (1998). 'Susceptibility of the tiger quoll, Dasyurus maculatus, and the eastern quoll, D. viverrinus, to 1080-poisoned baits in control programmes for vertebrate pests in eastern Australia', W*ildlife Research*, vol. 25, pp. 33–40.
117. Department of Environment, Water, Heritage and the Arts (2008). *Threat abatement plan for predation by feral cats*. Department of Environment Water Heritage and the Arts, Canberra.
118. Algar, D and Burrows, ND (2004). 'Feral cat control research: Western Shield review, February 2003', *Conservation Science Western Australia*, vol. 5, issue 2, pp. 131–163.
119. Algar, D and Richards, J (2010). 'Controlling introduced predators in the rangelands – the conclusion', *LANDSCOPE*, vol. 25, issue 4, pp. 17–23.
120. Hawke's Bay Regional Council (2003). *Animal pest control: rabbit control in urban areas*. Hawke's Bay Regional Council, New Zealand.
121. Bloomfield, T (2001). *Landcare note 296: Rabbit control using Pindone poison*. Department of Natural Resources and Environment, Victoria.
122. Lowe, T and Twigg, L (2007). *Pestnote 241: rabbit control in urban and semi-urban areas*. Department of Agriculture and Food, Perth, Western Australia.
123. Sharp, T and Saunders, G (2002). *Diffusion fumigation of rabbit warrens*. Department of Primary Industries, NSW.
124. Hayward, JS and Lisson, PA (1978). 'Carbon dioxide tolerance of rabbits and its relation to burrow fumigation', *Australian Wildlife Research*, vol. 5, pp. 253–261.
125. Lowe, T and Twigg, L (2007). *Farmnote 279: fumigation for rabbit control*. Department of Agriculture and Food, Perth, Western Australia.
126. Bloomfield, T (1999). *Landcare note 295: Rabbits - methods of fumigating rabbit burrows*. Department of Natural Resources and Environment, Victoria.
127. Department of Environment Water Heritage and the Arts (2008). *Background document for the threat abatement plan for competition and land degradation by rabbits*. Department of Environment, Water, Heritage and the Arts, Canberra, ACT. www.environment.gov.au/biodiversity/threatened/tap-approved.html.
128. NSW Department of Primary Industries (2004). *Model code of practice for the humane control of rabbits*. Prepared by T Sharp and G Saunders, the Department of the Environment and Heritage, Canberra, ACT. www.environment.gov.au/biodiversity/invasive/publications/pubs/cop-rabbits.pdf.
129. Williams, K, Parer, I, Coman, B J, Burley, J, and Braysher, M (1995). *Managing vertebrate pests: rabbits*. Bureau of Resource Sciences and CSIRO Division of Wildlife and Ecology, Australian Government Publishing Service
130. Koehn, J, Brumley, A, and Gehrke, PC (2000). *Managing the impacts of carp*. Bureau of rural Sciences.
131. Beaumont, W R C, Taylor, A A L, Lee, M J, and Welton, J S (2002). *Guidelines for Electric Fishing Best Practice*. Environment Agency, Bristol. http://publications.environment-agency.gov.uk/pdf/SW2-054-TR-e-e.pdf.
132. Snyder, DE (2004). 'Invited overview: conclusions from a review of electrofishing and its harmful effects on fish', *Reviews in Fish Biology and Fisheries*, vol. 13, pp. 445–453.
133. Rayner, T (2007). *Australian code of electrofishing practice*. Standing Committee for Fisheries and Aquaculture, Canberra, ACT. www.electrofishing.net/2008/08/27/australian-code-of-electrofishing-practice/.
134. Lawrence, C (2005). *Yabbie hybrid growout experiment*. Department of Fisheries, Perth, Western Australia. www.fish.wa.gov.au/docs/frr/frcr011/frcr011.pdf.
135. Department of Environment and Conservation (2007). *Prevention and control of damage by animals in WA: Australian white ibis Threskiornis molucca*. Department of Environment and Conservation, Perth, Western Australia. www.dec.wa.gov.au/index2.php?option=com_docman&task=doc_view&gid=278&Itemid=99999999.

136. Patrick, K (2006). 'Australian white ibis management at landfills at south east Queensland and north east NSW', in Ecosure Pty Ltd (Ed.), Ibis management conference, John Flynn Hospital, Gold Coast, 9/5/2006.
137. Shenton college students (2009). *Masons Gardens Lake Dalkeith: Aquatic fauna survey and rehabilitation of the natural lake ecosystem to control mosquitoes and algae*. Unpublished report
138. Lund, M (2007). *Getting rid of mosquitofish*. www.chs.ecu.edu.au/wetlands/mlund/wetlands_research/exotic/getting_rid_of_mosquitofish.htm.
139. Department of Environment and Conservation (2009). *Cane toad strategy for Western Australia 2009–2019*. Government of Western Australia, Perth, Western Australia. www.dec.wa.gov.au/canetoads.
140. Stop the Toad Foundation (2007). *Stop the Toad Foundation (STTF) report on outcomes of the 2007 Great Toad Muster*. Stop the Toad Foundation
141. Cooper, DW (2009). 'Should immunocontraception be used for wildlife population management?', *Australian Mammalogy*, vol. 26, pp. 61–65.
142. Thomson, PC, Marlow, NJ, Rose, K, and Kok, NE (2000). 'The effectiveness of a large-scale baiting campaign and an evaluation of a buffer zone strategy for fox control', *Wildlife Research*, vol. 27, pp. 465–472.
143. Pech, RP, Hood, GM, McIlroy, JC, and Saunders, G (1997). 'Can foxes be controlled by reducing their fertility?', *Reproduction, Fertility and Development*, vol. 9, pp. 41–50.
144. Department of Agriculture and Food (2010). *Invasive species*. Department of Agriculture and Food, Perth, Western Australia. www.agric.wa.gov.au/PC_92738.html?s=420205069,Topic=PC_92738.
145. Department of Health Pesticides Advisory Committee (2009). *A guide to the management of pesticides in local government pest control programs in Western Australia*. Department of Health, Perth, Western Australia. www.public.health.wa.gov.au/cproot/2663/2/A%20guide%20to%20the%20management%20of%20pesticides%20in%20local%20government%20pest%20control%20programs%20in%20Western%20Australia.pdf.
146. Department of Agriculture and Food (2000). *Farmnote 122/2000 [reviewed 2008] Feral camel*. Department of Agriculture and Food, Perth, Western Australia. www.agric.wa.gov.au/PC_93063.html?s=420205069.
147. Department of Agriculture (2000). *Farmnote 121/2000 [reviewed 2007] Feral donkey*. Department of Agriculture, Perth, Western Australia. www.agric.wa.gov.au/PC_93063.html?s=420205069.
148. Department of Fisheries (2010). *Freshwater fish distribution in Western Australia database*. Department of Fisheries, Perth, Western Australia. www.freshwater.fish.wa.gov.au.
149. Morgan, DL, Gill, HS, Maddern, MG, and Beatty, SJ (2004). 'Distribution and impacts of introduced freshwater fishes in Western Australia', *New Zealand Journal of Marine and Freshwater Research*, vol. 38, pp. 511–523.
150. Corfield, J, Diggles, B, Jubb, C, McDowall, R M, Moore, A, Richards, A, and Rowe, D K (2008). *Review of the impacts of introduced ornamental fish species that have established wild populations in Australia*. Prepared for the Australian Government Department of the Environment, Water, Heritage and the Arts, Commonwealth of Australia, Canberra, ACT. www.environment.gov.au/biodiversity/invasive/publications/pubs/ornamental-fish.pdf.
151. Department of Agriculture (2001). *Farmnote 91/2001 [reviewed 2005] Options for fox control*. Department of Agriculture, Perth, Western Australia. www.agric.wa.gov.au/PC_93061.html?s=420205069.
152. NSW Department of Primary Industries (2004). *Model code of practice for the humane control of foxes*. Prepared by T Sharp and G Saunders, the Department of the Environment and Heritage, Canberra, ACT. www.environment.gov.au/biodiversity/invasive/publications/pubs/cop-foxes.pdf.
153. Department of Agriculture (2000). *Farmnote 83/2000 [reviewed 2007] Feral goat*. By John James, Department of Agriculture, Perth, Western Australia. www.agric.wa.gov.au/PC_93063.html?s=420205069.

154. NSW Department of Primary Industries (2004). *Model code of practice for the humane control of feral goats*. Prepared by T Sharp and G Saunders, the Department of the Environment and Heritage, Canberra, ACT. www.environment.gov.au/biodiversity/invasive/publications/pubs/cop-feral-goats.pdf.
155. NSW Department of Primary Industries (2004). *Model code of practice for the humane control of feral horses*. Prepared by T Sharp and G Saunders, the Department of the Environment and Heritage, Canberra, ACT. www.environment.gov.au/biodiversity/invasive/publications/pubs/cop-feral-horses.pdf.
156. Department of Environment and Conservation (2007). *Fauna Note No. 29: Western Grey Kangaroo*. Department of Environment and Conservation, Perth, Western Australia. www.dec.wa.gov.au/content/category/43/853/1980/.
157. Department of Environment and Conservation (2007). *Fauna Note No. 30: Western Grey Kangaroo management plan*. Department of Environment and Conservation, Perth, Western Australia. www.dec.wa.gov.au/content/category/43/853/1980/.
158. Department of Agriculture (2003). *Farmnote 36/2003 [reviewed 2007] Feral pig control by trapping*. Department of Agriculture, Perth, Western Australia.
159. NSW Department of Primary Industries (2004). *Model code of practice for the humane control of feral pigs*. Prepared by T Sharp & G Saunders, the Department of the Environment and Heritage, Canberra, ACT. www.environment.gov.au/biodiversity/invasive/publications/pubs/cop-feral-pigs.pdf.
160. Department of Agriculture (2005). *Farmnote 89/2001 [reviewed 2007]: Options for rabbit control*. Department of Agriculture, Perth, Western Australia. www.agric.wa.gov.au/content/pw/vp/fer/f11000.pdf.
161. Morgan, DL, Beatty, SJ, Klunziger, MW, Allen, MG, Burnham, QF (2011), *A field guide to freshwater fishes, crayfishes and mussels of south-western Australia*, SERCUL and Murdoch University, Perth, Western Australia.

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