AUSTRALIAN VETERINARY EMERGENCY PLAN

AUSVETPLAN

Operational Procedures Manual

Wild Animal Response Strategy

Version 3.3, 2011

AUSVETPLAN is a series of technical response plans that describe the proposed Australian approach to an emergency animal disease incident. The documents provide guidance based on sound analysis, linking policy, strategies, implementation, coordination and emergency-management plans.

Primary Industries Ministerial Council

This wild animal response strategy forms part of:

AUSVETPLAN Edition 3

This manual will be reviewed regularly. Suggestions and recommendations for amendments should be forwarded to:

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DISEASE WATCH HOTLINE

1800 675 888

The Disease Watch Hotline is a toll-free telephone number that connects callers to the relevant state or territory officer to report concerns about any potential emergency disease situation. Anyone suspecting an emergency disease outbreak should use this number to get immediate advice and assistance.

Preface

This operational procedures manual for the management of wild animals is an integral part of the **Australian Veterinary Emergency Plan**, or **AUSVETPLAN (Edition 3)**. AUSVETPLAN structures and functions are described in the AUSVETPLAN **Summary Document**.

This manual sets out the management strategies and overall control procedures for wild terrestrial animals for use in an animal health emergency in Australia. It was approved by the former Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (now replaced by the Primary Industries Ministerial Council, PIMC) out of session in December 1999, and was updated in 2005 and again in 2011.

Much of the original research for this manual (especially in relation to the ecology of species) and collation of background data was funded by the Australian Government's Wildlife and Exotic Diseases Program.

Text placed in square brackets [xxx] indicates that that aspect of the manual remains contentious or is under development; such text is not part of the official manual. The issues will be worked on by experts and relevant text included at a future date.

Detailed instructions for the field implementation of AUSVETPLAN are contained in the disease strategies, operational procedures manuals, management manuals and wild animal manual. Industry-specific information is given in the relevant enterprise manuals. The full list of AUSVETPLAN manuals that may need to be accessed in an emergency is shown below.

In addition, *Exotic Diseases of Animals: A Field Guide for Australian Veterinarians* by WA Geering, AJ Forman and MJ Nunn, Australian Government Publishing Service, Canberra, 1995 (to be updated) is a source for some of the information about the aetiology, diagnosis and epidemiology of the diseases.

Earlier versions of this manual were prepared by a writing group with representatives from the Australian national, state and territory governments and industry. Recent versions of the document were reviewed and updated by Glen Saunders (versions 3.2 and 3.3) and Lynette McLeod (version 3.3) of the New South Wales Department of Primary Industries.

AUSVETPLAN documents[1]

Disease strategies

Individual strategies for each of 35 diseases

Bee diseases and pests

Response policy briefs (for diseases not covered by individual manuals)

Operational procedures manuals

Decontamination

Destruction of animals

Disposal

Livestock welfare and management

Public relations

Valuation and compensation

Enterprise manuals

Artificial breeding centres

Feedlots

Meat processing

Saleyards and transport

Poultry industry

Zoos

Management manuals

Control centres management (Parts 1 and 2)

Laboratory preparedness

Wild animal response strategy

Summary document

[1] The complete series of AUSVETPLAN documents is available on the internet at www.animalhealthaustralia.com.au/programs/emergency-animal-disease-preparedness/ausvetplan/

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Part A Strategic guidelines

Part A of this manual provides information needed for strategic planning of wild animal management programs:

- Section 1 — An introduction to wild animals in Australia, legislation and codes of practice.
- Section 2 — Emergency animal diseases of concern.
- Section 3 — Wild animal species, ecology and biology.
- Section 4 — Principles of disease control.
- Section 5 — A key for decision making.

1 Introduction

This manual has been written to assist with the management of wild animals in an emergency animal disease (EAD) outbreak. For information on how the procedures outlined in this manual link with other components of AUSVETPLAN, see the summary section of the **Summary Document**.

1.1 What are wild animals?

Wild terrestrial animals include:

- *feral animals* — domestic animals that are not confined or under control (eg cats, horses, pigs);
- *exotic fauna* — nondomestic animal species that are not indigenous to Australia (eg foxes); and
- *native wildlife* — animals that are indigenous to Australia and may be susceptible to EADs (eg bats, dingoes and marsupials).

Feral animals and some introduced wild animals are often collectively referred to as *vertebrate pests.* These animals may be important in maintaining or transmitting livestock diseases, and specific control activities may be necessary. Their involvement may also complicate the demonstration of disease freedom at the end of an eradication program. In other cases, their involvement may be incidental (eg when they are 'dead-end' hosts) and no further action may be required.

Australia is fortunate that most native wildlife species do not appear to be at significant risk from many of the EADs of concern (see the **Summary Document** and the **Zoos Enterprise Manual**). However, there are significant populations of feral animals and wildlife that are undoubtedly susceptible to the same diseases as their domestic counterparts.

The key species covered by this manual are:

- *large feral herbivores* — buffalo, camels, cattle, deer, donkeys, goats and horses;
- *feral pigs* — also referred to as wild pigs; and
- *wild carnivores* — introduced foxes, feral and stray cats, wild and stray (urban) dogs, and native dingoes.

Other particular species include wild birds and bats. Rodents are considered in a minor way in this manual; with the exception of Aujeszky's disease, their most likely association with EADs is commensal (Caughley et al 1998). Native species are not considered in detail.

In an outbreak, commercial operators (such as pest controllers and kangaroo harvesters) are most likely to undertake control measures in wild animals under direction from government agencies.[2] However, it is unlikely that any major control activities would be undertaken for most native wildlife species and rodents,

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[2] Control measures need to take into account legislation protecting native wild animals.

although incident managers may collect samples from these species for disease surveillance.

Local knowledge is essential in assessing the status of wildlife populations. Wildlife/vertebrate pest technical experts, species experts or wildlife biologists should be consulted to obtain current and local information on the ecology and behaviour of susceptible wild animal species.

1.2 Legislation and codes of practice

Legislation for the purpose of controlling EADs has been enacted at national and state levels. The national legislation is primarily concerned with preventing the introduction and establishment of disease or things that may carry disease. Statutory provisions exist in all states and territories for the control and eradication of disease in animals. These provide for controls over animal movement, treatment, decontamination, slaughter and compensation. Wide powers are conferred on government inspectors, including the power to enter premises, order stock musters, test animals, and order the destruction of animals and animal products that are suspected of being infected or contaminated.

Some state and territory legislation may impinge on certain activities directed at controlling wild animals during an EAD outbreak, such as:

- agricultural and veterinary chemicals, dangerous goods and environment protection legislation covering the use of vertebrate pest poisons and baits;
- workplace health and safety legislation;
- animal welfare legislation;
- legislation designed to protect endangered flora and fauna, and sites of importance to Indigenous communities (the types of control activities that may be undertaken may vary between states);
- other conservation legislation;
- legislation covering the use of firearms and aircraft; and
- legislation requiring landholders to suppress or destroy (or both) various species of wild animals that pose a threat to agricultural production and the environment.

It is essential that the appropriate national, state and territory legislation be recognised, understood and adhered to when implementing any of the procedures outlined in this manual. Appendix 4 lists legislation by state and territory.

Animal welfare is an important consideration when undertaking the control of wild animals. Codes of practice and standard operating procedures (Sharp and Saunders 2005) have been developed for each of the key pest animal species, providing information on best-practice management, control strategies, species biology and impact, and the humaneness of current control methods. These documents should be consulted if wild animal control is necessary during an EAD outbreak.

2 Emergency diseases of concern

2.1 Major emergency diseases that may affect wild animals

A brief introductory summary of each emergency animal disease (EAD) that may affect wild animals is provided below. The list is limited to those diseases for which AUSVETPLAN disease strategies and response policy briefs have been produced. See Sections 1.2 and 1.4 of the relevant disease strategies for information on susceptible species, clinical signs and human health implications. Further information is also available in Rose (2005) and in the fact sheets on the Australian Wildlife Health Network website[3] and feral.org.au.[4] Table 2.1 summarises the disease susceptibility of wild animal species.

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[3] www.wildlifehealth.org.au/AWHN/FactSheets/Fact_All.aspx

[4] www.feral.org.au/pathogens-in-vertebrate-pests-in-australia

Table 2.1 Major emergency diseases that may affect wild animal species

Disease	Horse	Pig	Goat	Deer	Cattle	Buffalo	Camel	Donkey	Fox	Dog	Cat	Bird	Bat	Rodent/rabbit
African horse sickness														
African swine fever														
Anthrax														
Aujeszky's disease														
Australian bat lyssavirus														
Avian influenza														
Bluetongue														
Brucellosis														
Classical swine fever														
Contagious bovine pleuropneumonia														
Contagious equine metritis														
Equine influenza														
Foot-and-mouth disease														
Japanese encephalitis														
Lumpy skin disease														
Newcastle disease														
Peste des petits ruminants														
Porcine reproductive and respiratory syndrome														
Rabies														
Rift Valley fever														

Disease	Horse	Pig	Goat	Deer	Cattle	Buffalo	Camel	Donkey	Fox	Dog	Cat	Bird	Bat	Rodent/rabbit
Screw-worm fly	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Sheep pox and goat pox			■											
Surra	■	■	■	■	■	■	■	■	■	■	■			■
Swine vesicular disease		■												
Transmissible gastroenteritis		■							■	■	■			
Vesicular exanthema		■												
Vesicular stomatitis	■	■		■	■	■		■					■	■

■ Susceptible; Unknown susceptibility; Not susceptible

2.1.1 African horse sickness

African horse sickness (AHS) is an infectious, insect-borne viral disease of horses, donkeys and mules. Horses are more susceptible than mules and, generally, donkeys have a lower susceptibility. AHS is frequently fatal in susceptible horses. The virus is transmitted by midges (*Culicoides* spp.), so there is a seasonal incidence in temperate climates. Recovered horses develop good immunity to the serotype that infected them, but remain susceptible to other serotypes. Horses do not become long-term carriers. Dogs can become infected through eating viraemic animals and usually contract a fatal form of the disease. Dogs are not a favoured host for *Culicoides*, and it is doubtful whether dogs play any role in the spread or maintenance of the disease virus.

Susceptible wild animals are horses, donkeys and dogs.

2.1.2 African swine fever

African swine fever (ASF) is a highly contagious, generalised viral disease affecting only pigs. It is transmitted by direct contact, inanimate objects and ticks. The virus is very resistant to inactivation. The acute form of the disease is characterised by a mortality of up to 100% in infected herds. Milder forms of the disease also occur.

Pigs that survive acute disease or are infected by mild strains can become chronically infected for several months, although virus is thought to be excreted for only 5–6 weeks. In Europe, wild pigs can become infected and may be a reservoir of infection for domestic pigs.

Susceptible wild animals are pigs.

2.1.3 Anthrax

Anthrax is an acute, infectious bacterial disease that can affect humans and a wide range of domestic and wild animals. Ruminants tend to be the most susceptible; however, all mammals are susceptible to some degree. The clinical forms of anthrax in animals are traditionally described as:

- peracute (very acute), in which death occurs suddenly (within a few hours at most of the onset of clinical signs);
- acute, in which death occurs from 24 hours to a few days after onset; and
- subacute or localised, which lasts for several days and may end in recovery.

In cattle, sheep and goats, the disease is usually peracute; in horses it is acute; and in pigs, dogs and cats it is localised.

Anthrax in Australia is confined to certain regions and only occurs exceptionally.

The disease has been reported in captive macropods overseas (Sen Gupta 1974), but has not been reported in free-ranging macropods in Australia.

Susceptible wild animals include most warm-blooded animals; for example, cattle, sheep, goats, horses, deer, camels, pigs, dogs, cats and raptors.

2.1.4 Aujeszky's disease (pseudorabies)

Aujeszky's disease is caused by a herpesvirus that infects the nervous system and other organs, such as the respiratory tract. The pig is the only natural host for the disease. Sporadic cases occur in cattle, buffalo, sheep, goats, dogs, cats, foxes, mink, deer, rabbits, mice and rats. The disease is usually fatal in these other species. There have been no substantiated reports of human infection. Ruminants are generally considered to be ‘dead-end’ hosts. Rodents and wild animals may have a role in maintaining and spreading the disease. In dogs and cats, there can be intense pruritus, paralysis of the throat and convulsions, with death occurring within 48 hours in dogs and often more rapidly in cats. Pigs may remain latently infected following clinical recovery.

Susceptible wild animals are pigs, cattle, buffalo, goats, sheep, deer, camels, dogs, cats, foxes and rats.

2.1.5 Australian bat lyssavirus

Australian bat lyssavirus (ABLV) is closely related to European bat lyssavirus and classical rabies virus. ABLV infection has been detected in four species of fruit bats (the black flying-fox, *Pteropus alecto*; the little red flying fox, *P. scapulatus*; the grey-headed flying fox, *P. polioencephalus*; and the spectacled flying fox, *P. conspicillatus*) and one species of insectivorous bat (the yellow-bellied sheath-tailed bat, *Saccolaimus flaviventris*). These bats are believed to be the primary reservoir for the virus. Serological evidence of exposure to ABLV has been reported in seven genera, representing five of the six families of Australian Microchiroptera (Field 2005). Hence, all Australian bat species are considered susceptible to ABLV.

ABLV is transmissible to humans directly from bats, without an intermediate host, and there have been two human fatalities since identification of ABLV in 1996. The rabies vaccine and immunoglobulin offer effective prophylactic and therapeutic protection from ABLV infection.

Occasional transmission of ABLV to other mammalian species is likely. Transmission of ABLV to individual animals of other species is unlikely to result in the establishment of persistent cycles in these species, as this would require adaptation of the virus strain to the new host species. Little is known about the host range and pathogenicity of ABLV in mammals other than bats and humans.

Susceptible wild animals are bats; the susceptibility of other wild species is unknown.

2.1.6 Avian influenza

Highly pathogenic avian influenza is a lethal, generalised disease of poultry caused by specific types of avian influenza virus. Disease outbreaks occur most frequently in chickens and turkeys. Many wild bird species, particularly waterbirds and seabirds, are also susceptible, but infections are generally subclinical. Historically, humans have not been affected, but more than 310 people have died from H5N1 infections during the past 10 years, principally in Southeast Asian countries. Waterbirds are suspected of being the source of infection for domestic poultry in many outbreaks, including those that have occurred in Australia. Destruction of wild birds is impractical, and control should centre on ensuring that wild birds do not come into contact with domestic birds. Some disease sampling of wild birds may be required. Infection with some serotypes and disease have been recorded in several carnivorous species, including foxes, dogs and cats. Also, there have been some cases in free-living donkey populations (Reperant et al 2008, Abdel-Moneim et al 2010, Chen et al 2010).

Susceptible wild animals are many species of wild birds (especially waterbirds), carnivores, rodents, pigs, cattle, equines and rabbits.

2.1.7 Bluetongue

Bluetongue is a viral disease of ruminants transmitted only by particular species of biting midges (*Culicoides* spp.). Sheep are the most severely infected; infection in cattle is generally subclinical. Naturally occurring disease has not been seen in Australia, although serotypes of the virus, some pathogenic, have been detected in northern and eastern Australia.

Susceptible wild animals are cattle, goats, sheep, buffalo and deer, and possibly camels.

2.1.8 Brucellosis

Bovine brucellosis is a chronic infectious disease of cattle caused by the bacterium *Brucella abortus*, an intracellular parasite. Bovine brucellosis results in abortion, stillbirth, infertility and reduced milk production. The disease was effectively eradicated in Australia by 1989. Other *Brucella* species infect pigs, sheep, goats, dogs, marine mammals and rodents. Cross-infection of cattle by these species is usually limited to a single animal, but the pig bacterium *B. suis* has become established in cattle in South America. Humans are susceptible.

Susceptible wild animals are cattle, buffalo, sheep, deer and rodents.

2.1.9 Classical swine fever (hog cholera)

Classical swine fever is a highly contagious and usually fatal viral disease, which is capable of spreading rapidly in susceptible pig populations. Strains of lower virulence cause subacute and chronic forms of the disease. Some pigs can become subclinical carriers of the disease. In Europe, wild pigs play an important epidemiological role in this disease; however, it rarely becomes endemic at a localised site (Artois et al 2002).

Susceptible wild animals are pigs.

2.1.10 Contagious bovine pleuropneumonia

Contagious bovine pleuropneumonia is a contagious bacterial disease that afflicts the lungs of cattle, buffalo, zebu and yaks. Sheep, goats, camels, antelope and wild bovids are resistant to the disease. Humans are also unaffected. The bacterium is widespread in Africa, the Middle East, southern Europe and parts of Asia. It is an airborne bacterium and can travel up to several kilometres under certain conditions.

Susceptible wild animals are buffalo and cattle.

2.1.11 Contagious equine metritis

Contagious equine metritis (CEM) is a sexually transmitted disease of horses that causes endometritis (inflammation of the lining of the uterus) and temporary infertility in mares. It is sometimes associated with cervicitis, vaginitis and, rarely, abortion. Both sexes can be inapparent carriers of the disease bacterium *Taylorella equigenitalis*, strains of which vary in pathogenicity. CEM can be spread mechanically by contact with infectious discharges and contaminated fomites. All breeds of horses are susceptible, and donkeys can be infected experimentally.

Susceptible wild animals are horses and donkeys.

2.1.12 Equine influenza

Equine influenza is an acute respiratory viral disease that may cause rapidly spreading outbreaks in congregated horses. It is caused by two members of the genus *Influenzavirus*. Other equines are susceptible, and particularly severe disease has been seen in donkeys. Feral horses and donkeys are unlikely to serve as a source of infection to domestic horses because close, direct contact is required to spread the disease, and the virus retains infectivity in the environment for only a couple of days. In 2004 in the United States, a virus closely related to contemporary equine influenza A virus subtype H3N8 became established in canine populations, causing acute respiratory disease. Nucleotide sequence identity studies suggest direct transmission of the entire equine virus to dogs, with subsequent divergence (Payungporn et al 2008).

Susceptible wild animals are horses, donkeys and dogs.

2.1.13 Foot-and-mouth disease

Foot-and-mouth disease (FMD) is an acute, highly contagious viral infection of domestic and wild cloven-hoofed animals. Serious production losses can occur, but deaths are unlikely except among young animals. Pigs are considered important amplifying hosts because of their susceptibility to oral infection and their capacity to excrete large amounts of virus. Cattle are considered good indicators of the presence of the disease because of their high sensitivity to infection. Sheep and goats are often considered maintenance hosts because disease can be present with few clinical signs. Ruminants, but not pigs, can become carriers of the virus. The role of carrier animals in the transmission of FMD virus has been uncertain, and transmission from carrier to susceptible cattle has never been experimentally demonstrated. However, there is now clear evidence from Africa of transmission from carrier buffalo and cattle under field conditions (Dawe et al 1994, Geering et al 1995).

FMD has been known to occur in marsupials (Bhattacharya et al 2003). Experimental studies on a variety of native animals showed virus replication, viraemia and shedding in many of the species studied. Natural transmission from cattle to red kangaroos and wombats occurred when the animals were held together. However, native species are unlikely to have a significant role in an outbreak under natural field conditions (Snowdon 1968).

Susceptible wild animals are cattle, buffalo, sheep, deer, pigs, goats, camels, native species, such as marsupials, and rodents.

2.1.14 Japanese encephalitis

Japanese encephalitis (JE) is an acute, mosquito-borne viral disease of humans and other animals, mainly pigs and horses, which occurs throughout much of Asia. JE infection causes abortion, stillbirths or mummified foetuses in sows, and fever and encephalitis with deaths in piglets, horses and humans. Waterbirds (herons and egrets) are the main reservoir for spreading the JE virus and, together with pigs, are important amplifying hosts. Inapparent infections occur in cattle, sheep, goats, dogs, cats, rodents, snakes and frogs. Several species of bats are susceptible to the virus, and recent work suggests that flying foxes may play a role in virus dispersal (Van den Hurk et al 2009). The susceptibility of other native fauna is not known, but they may prove to be significant hosts.

Susceptible wild animals are pigs, horses and bats; inapparent infections occur in cattle, sheep, goats, dogs, cats, rodents, snakes and frogs.

2.1.15 Lumpy skin disease

Lumpy skin disease is an acute, highly infectious, generalised viral skin disease of cattle. It is caused by a member of the *Capripox* virus genus, similar to the virus that causes sheep pox and goat pox. Biting flies and mosquitoes are thought to transmit the virus mechanically. Cattle are thought to be the maintenance host, and feral cattle and buffalo could be a source of infection for domestic animals.

Susceptible wild animals are cattle and buffalo.

2.1.16 Newcastle disease

Newcastle disease (ND) is a highly contagious and lethal viral disease of chickens, turkeys and other domestic birds. Many species of wild birds are susceptible, but may not demonstrate classical clinical signs. Natural infection has been reported in humans and rodents, and a variety of laboratory animals have been infected experimentally. Parrots and pigeons have been implicated in outbreaks overseas. The importance of non-avian species in the spread of ND is not known. Viral strains vary widely in their virulence; severe strains cause rapid death. During migration, it is expected that wild waterfowl that are more susceptible to ND will be weakened or moribund. Destruction of wild birds is impractical, and control should centre on ensuring that wild birds do not come into contact with domestic birds. Some sampling of wild birds may be required.

Susceptible wild animals include many species of wild birds.

2.1.17 Peste des petits ruminants

Peste des petits ruminants (PPR) in sheep and goats resembles rinderpest of cattle (see Section 2.1.21) and is caused by a closely related virus. PPR produces high morbidity and mortality. It tends to be more severe in goats than in sheep. Recovered animals do not become chronic carriers. Some species of deer have been infected during natural outbreaks; however, wild animals do not seem to have an important role in the epidemiology of PPR.

Susceptible wild animals are goats, sheep and deer.

2.1.18 Porcine reproductive and respiratory syndrome

Porcine reproductive and respiratory syndrome is caused by an RNA virus of the genus *Arterivirus*, which infects macrophages and thus compromises the immune response in pigs. Infected herds experience late-term abortions and stillbirths, weakness, reduced fertility, severe respiratory disease, high mortality among suckling and weaned pigs, deaths, and a delayed return to oestrus among sows. However, some infected herds show no symptoms. There has been some evidence that ducks can be infected under experimental conditions (Zimmerman et al 1997), but waterfowl are not considered to play any role in natural disease spread.

Susceptible wild animals are pigs.

2.1.19 Rabies

Rabies is an almost invariably fatal viral encephalitis affecting all warm-blooded animals, although birds are of very limited importance in its epidemiology. It has a long and variable incubation, and is transmitted by the bite of a rabid animal. Although the virus can infect a wide range of species, in any given region it tends to be maintained by a particular species to which the virus is adapted (ie biotypes). In different parts of the world, different species can be reservoir hosts. The main reservoir species are from the orders Carnivora or Chiroptera. Dogs are the main species responsible for maintaining and spreading rabies in urban environments; dogs also present the main risk of spreading disease to people. Reservoir wildlife hosts include members of the family Canidae (eg wild dogs, foxes, jackals, wolves), and raccoon, skunk, mongoose, meerkat and bat species. If rabies is controlled in the reservoir species, the disease tends to die out. It is extremely important to determine the strain of virus involved, as this will establish the key animals that need to be targeted in control programs. Depending on the strain introduced, rabies could become established in Australia, with wild dogs, foxes, bats or cats as reservoir hosts (Saunders 1999). A lyssavirus, closely related to rabies, is present in bats in Australia (see Section 2.1.5).

Susceptible wild animals are mammals; dogs, cats, foxes and bats are all potential hosts. Many other species are susceptible to spill-over events.

2.1.20 Rift Valley fever

Rift Valley fever is a mosquito-borne viral disease affecting a wide range of vertebrate hosts. Mosquitoes are believed to maintain the virus, which can remain in dormant mosquito eggs for several years. Cattle, sheep, goats and humans are the major species affected; amplification of the virus occurs in cattle. The disease is characterised by high rates of abortion and high rates of mortality in young animals. Severe disease can occur in humans, so special safety precautions are required. The susceptibility of Australian native fauna is unknown.

Susceptible wild animals are goats, cattle, buffalo, sheep, camels, donkeys, horses, dogs, cats and rodents, and possibly foxes.

2.1.21 Rinderpest

Rinderpest is an acute, highly contagious viral disease, for which cattle and buffalo are the major hosts. On its own, the virus is not stable in the environment. The virus is related to the viruses that cause measles, canine distemper and PPR. As well as cattle and buffalo, rinderpest affects many other cloven-hoofed wild animal species in Africa, including giraffe, eland and kudu. Infection in wild cloven-hoofed animals, with strains maintained mainly in cattle, causes a wide spectrum of disease, from very severe to subclinical. Sheep and goats may develop clinical signs, but serious disease is uncommon. Disease occurs but may be inapparent in camels and deer. Asian pigs seem more susceptible than African and European varieties. Humans are not affected.

Because of their isolated populations, feral cattle and buffalo are unlikely to play a major role in spreading the disease in Australia. The potential role, if any, of feral pigs in spreading the disease in Australia is unclear.

Susceptible wild animals are cattle, pigs, goats, buffalo, sheep and camels.

2.1.22 Screw-worm fly

The screw-worm fly (SWF) is a member of the blowfly family Calliphoridae, and its larvae are obligate parasites on warm-blooded animals. There are two species of concern: *Chrysomya bezziana* (Old World SWF) and *Cochliomyia hominivorax* (New

World SWF). The larvae feed on living tissues and associated fluids in open wounds, causing myiasis (the parasitism of animal tissues by blowfly larvae), which results in debility and some deaths. The flies prefer warm, moist conditions with temperatures of 16–30 °C. All warm-blooded animals, including humans, are susceptible to infestation, although the greatest economic losses are experienced in cattle, sheep and goats. Australian native species have been shown to be susceptible. Screw-worm myiasis is rarely seen in birds.

Susceptible wild animals are potentially all wildlife and feral animal species.

2.1.23 Sheep pox and goat pox

Sheep pox and goat pox are highly contagious viral diseases, often with a high mortality rate. They are both caused by members of the *Capripox* virus genus, similar to the virus that causes lumpy skin disease in cattle. Sheep pox and goat pox are generally specific to sheep and goats, respectively, but strains from some areas have been reported to affect both species. The viruses are very resistant to inactivation in the environment, and insects may be involved in spreading them. Feral goats could be involved in maintaining the disease in some areas of Australia.

Susceptible wild animals are goats and sheep.

2.1.24 Surra

Surra is a haemoparasitic disease caused by the trypanosome *Trypanosoma evansi*, which is transmitted by biting flies among a wide range of host species. Infection causes fever, weight loss, anaemia and other symptoms, and results in high mortality among immunologically naive animals. The disease is most severe in horses, donkeys, mules, deer, camels, and domestic dogs and cats, but also occurs in mild, chronic or subclinical forms in cattle, alpacas, llamas, buffalo, sheep, goats, pigs, capybaras and elephants. Two wallaby species can be infected experimentally, but the susceptibility of other Australian native species is unknown. Dingoes and feral pigs should be considered as potential hosts. Infection has been reported in foxes in Asia, and rats, mice, guinea pigs and rabbits are susceptible to infection in the laboratory.

Susceptible wild animals are horses, donkeys, deer, camels, dogs, cats, cattle, buffalo, goats, sheep, pigs, foxes, rodents and rabbits.

2.1.25 Swine vesicular disease

Swine vesicular disease (SVD) is an acute, highly contagious viral disease of pigs caused by an enterovirus of the family Picornaviridae, closely related to the human coxsackievirus B5. The disease is characterised by fever and lameness caused by the formation of vesicles on the feet and lower limbs, and to a lesser extent on the snout. It is clinically indistinguishable from FMD. The SVD virus is highly resistant to inactivation. Pigs are mainly infected by ingestion of infected feedstuff, direct contact with infected pigs or contact with contaminated surfaces. Feral pigs could become infected through eating contaminated garbage.

Susceptible wild animals are pigs.

2.1.26 Transmissible gastroenteritis

Transmissible gastroenteritis is an enteric viral disease of pigs, caused by a coronavirus, which results in rapid death of piglets less than 3 weeks of age. Disease occurs only in pigs, although dogs, cats and foxes are susceptible to infection. The virus is spread by the faecal–oral route, and starlings have also been implicated as possible mechanical vectors. Recovered pigs occasionally become carriers, and dogs, cats and foxes may be a source of infection for pigs.

Susceptible wild animals are pigs, dogs, cats and foxes.

2.1.27 Transmissible spongiform encephalopathies

The transmissible spongiform encephalopathies include bovine spongiform encephalopathy (BSE) in cattle, scrapie in sheep and goats, and chronic wasting disease (CWD) in deer. All are progressive degenerative diseases of the central nervous system and are always fatal. All are believed to be caused by an unconventional agent, usually called a prion.

Susceptible wild animals are cattle, buffalo, goats, sheep, deer and cats.

Bovine spongiform encephalopathy

Cattle are the main natural hosts of BSE. There are no known breed differences in susceptibility per se, but epidemiological studies overseas have indicated a much higher incidence in dairy breeds. Some cases of spongiform encephalopathy have also occurred in antelopes and cats (both domestic and exotic).

Scrapie

Sheep and goats are the main natural hosts of scrapie. Scrapie can be experimentally transmitted to mice, rats, hamsters, monkeys, and a wide range of other wild or laboratory species, as well as to its natural hosts.

Chronic wasting disease

CWD is a spongiform encephalopathy of cervids that was recognised in 1967 and has been identified in mule deer, white-tailed deer and elk in North America. CWD was originally confined to captive deer, but now many cases have occurred in free-ranging animals. CWD is transmissible and fatal. The main clinical signs are progressive weight loss, behavioural changes, excessive salivation, excessive water consumption and frequent urination. The pathology in the brain is typical of the other spongiform encephalopathies.

2.2.28 Vesicular exanthema

Clinically, vesicular exanthema (VE) is indistinguishable from FMD. The VE virus is closely related to a family of viruses that are isolated from marine animals. Disease in pigs has been associated with the feeding of contaminated food scraps containing marine animal product. The pig is the only terrestrial mammal in which VE has been observed under natural conditions.

Susceptible wild animals are pigs.

2.1.29 Vesicular stomatitis

Vesicular stomatitis (VS) is a viral disease, principally of cattle, horses and pigs. Sheep and goats are resistant and rarely become infected. VS can cause signs indistinguishable from those of FMD. The disease has been seen only in North, Central and South America. The epidemiology of VS is still unclear, but transmission cycles between insects and small wild ruminants are known to occur. A wide range of other species may be susceptible, including New World species of wildlife (eg deer, antelope, bighorn sheep, monkeys, racoons, skunks, rodents and bats).

Susceptible wild animals are horses, donkeys, cattle, buffalo and pigs; and possibly deer, rodents and bats.

3 Species ecology and biology

3.1 Introduction

This section provides information on the ecological factors that affect the likelihood that a wild animal species will contract, maintain or spread disease (or all three). Factors influencing whether or not an animal becomes infected and succumbs to disease are complex.

A number of ecological factors affect the transmission, rate of spread and maintenance of disease within a population, and the dispersal and density of the population:

- *Population distribution and density*. This affects contact rates between susceptible and infective animals. Disease maintenance and transmission are facilitated at higher densities, while the distribution of wildlife (eg isolated versus continuous) can determine the area over which a disease is likely to occur.
- *Habitat requirements and availability*. Animals generally have specific habitat requirements, and availability of habitats will vary with animal density, including that of other competing species. Rugged terrain may also hinder control operations. These factors and the specific requirements of the disease agent and its hosts will influence the spread and maintenance of emergency animal diseases (EADs).
- *Social organisation*. Group sizes and dominance hierarchies may affect disease transmission and maintenance. Herding versus solitary behaviour can affect the ability to detect disease within a population, while changes to social organisation at particular times of the year (eg breeding) can cause increases in contact rates and transmission. Territorial versus nonterritorial behaviour can also influence disease dynamics.
- *Reproductive status and seasonality*. Breeding and other seasonal behaviours (eg dispersal in response to food shortages or migration behaviour) will lead to variability in contact rates, as they can affect the home range size and the population density of hosts.
- *Age structure of population*. Disease dynamics differ between populations with a uniform age distribution and those with a high turnover. For example, diseases with a long latent period might be detected only in older animals, and age structure can affect the population’s immunity status and hence susceptibility to the disease and survivorship.
- *Home-range size*. This can determine the area over which a disease can potentially spread. Home-range size and density can also influence the conduct and effectiveness of control programs. As a general rule, the larger the animal, the larger the home range.
- *Movements and distances travelled*. There may be sex, seasonal and group effects. Some species (eg foxes) undergo yearly periods of dispersal, during which they can travel long distances in a short time. There can also be large variations in the rate of movement and distances travelled by individuals within populations at any time of the year.

- *Barriers to dispersal*. Some natural or artificial barriers will restrict movements of animals and hence the rate of disease spread. Thus, disease spread may be unidirectional. These barriers can also be used as geographical boundaries during control operations.
- *Response to disturbance*. In some cases, the imposition of control operations could cause animals to disperse from localised areas, although existing evidence suggests otherwise.
- *Interactions between wildlife species and domestic stock* (eg at watering points).

Local wildlife/vertebrate pest technical experts, species experts or wildlife biologists should be consulted to obtain current and local information on the ecology of susceptible wild animal species.

The role that wild animals would play in an EAD outbreak is unclear. There is enormous variation in the distribution, density and habits of wild animals between and within regions in Australia. Wild animals in Australia are generally difficult to manage. The success of control operations is also frustrated by the ability of some species to avoid detection; relocate to other, sometimes inaccessible, areas under the pressure of control or hunting; rapidly repopulate areas that have been subject to control operations; and breed year-round where water, food and other necessary resources are abundant.

Each disease will have a different effect on a population. As a guide, the key factors likely to influence the maintenance or transmission of an EAD and its control in each wild animal species are presented in Boxes 3.1–3.13 in the following sections. Some of the main ecological and biological attributes are shown in Tables 3.1–3.3 in Section 3.3.

3.2 Summaries of important ecological factors for wild animal species

Further information, including distribution maps, for some of the wild animal species in this section can be found at the website feral.org.au (hosted by the Invasive Animals Cooperative Research Centre and the Institute for Applied Ecology, University of Canberra).[5]

3.2.1 Bats (Chiroptera)

Bats belong to the order Chiroptera, which is divided into two suborders, Megachiroptera and Microchiroptera.

The Megachiroptera are fruit, blossom or nectar feeders, and include not only the larger bats, such as flying foxes or fruit bats, but also several small blossom bats. The four largest species are called flying foxes and belong to the genus *Pteropus*. The Australian range of the flying foxes extends from temperate eastern and coastal Australia into the eastern tropics, around the tropical northern coastline, and south as far as the subtropical west coast. The most common species — the little red flying fox — can be found in camps that include more than 100 000 individuals, a factor that would readily facilitate the transmission of disease agents (Plowright et al 2008).

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5 Lapidge K, Braysher M and Sarre S (2004–present). www.feral.org.au (Accessed 16 March 2011)

The Microchiroptera are small bats; in Australia they are all insectivorous, with one species being carnivorous as well. They are found in many parts of Australia, from the cold southern regions to the arid inland and the tropical north. Most southern species are insect eaters that roost in tree hollows or under bark, usually near water. Most insect-feeding bats in tropical Australia live in caves or old mines. During colder months, the bent-winged bat has been known to migrate several hundred kilometres to warmer areas.

The role that native Australian bats might play in an EAD outbreak is undefined. The great mobility of bats gives them the potential to transmit viruses over large distances. Overseas, bats are responsible for rabies infection spillovers in terrestrial mammals outside enzootic areas, but the disease does not appear to become established in these populations.

Several novel viruses have been discovered in Australia in the past decade. Two, and possibly three, of these are human pathogens, and Australian bats are considered to be natural hosts for all three of these viruses. The viruses are Hendra virus (formerly known as equine morbillivirus), which has been a cause of death in horses and humans; Menangle virus (formerly known as pig paramyxovirus), which causes foetal pig wastage and influenza-like illness in humans; and Australian bat lyssavirus, which has caused two human deaths (Mackenzie et al 2003).

Box 3.1 Key factors — bats

Factors that increase the risk of maintaining, transmitting and dispersing diseases

- Bats have a long lifespan (most bats live for about 10 years, but some may live up to about 25 years).
- The colonial habits of many bat species provide a highly efficient arena for the transmission of viruses from bat to bat.
- Feral predators, such as foxes, may be susceptible to infection when feeding on an infected bat.
- Fruit bats may engage in widespread seasonal migration in search of food.

Other factors

- Most of the 22 genera of Australian bats also occur in Papua New Guinea and Asia.
- Bats play a very important role in regulating insect populations, in plant pollination and in spreading seeds.
- Eradication of bats is not feasible. Habitat destruction in confined locations may reduce populations in that area.
- In all disease situations, unrealistic expectations of wild animal control or depopulation operations must be avoided.
- Some bat species are listed under state or territory, or federal legislation as threatened and protected; this must be considered in management plans.

3.2.2 Buffalo (*Bubalus bubalis*)

Water buffaloes were imported into northern areas of Australia from Southeast Asia in the 19th century, and are now widespread across northern Australian wetlands. The Brucellosis and Tuberculosis Eradication Campaign, which occurred in the 1980s and early 1990s, drastically reduced their distribution and density (Robinson and Whitehead 2003). However, as remnant populations went largely unchecked (Petty et al 2007) and the farming of redomesticated herds has become popular over the past decade, population numbers of feral buffalo are on the increase (Jesser et al 2008).

Box 3.2 Key factors — buffalo

Factors that increase the risk of maintaining, transmitting and dispersing diseases

- The distribution of feral buffalo overlaps that of domestic cattle and other feral animals.
- Feral buffalo occur along the Northern Territory coast, placing them at risk of contact with unauthorised boat landings.
- Feral buffalo are able to breed year-round where food and water are abundant.
- Their wallowing habits are likely to increase the probability of disease transmission to other species that drink from or share the wallows, especially pigs. Wallows also create environments that favour insect breeding, which are important in vector-borne diseases.
- In the wet season, bulls and cows (up to 500 animals) congregate for breeding, which may increase the probability of disease transmission.
- Under stress, a group may leave its home range and move into another group's home range.
- Control operations may alter the behaviour of surviving buffalo (eg feeding at night and retreating to cover during the day, and possibly hiding from aircraft), making it difficult to locate residual animals.

Factors that reduce the risk

- The distribution of feral buffalo is limited, being confined to the 'Top End' of the Northern Territory.
- Feral buffalo do not tend to move great distances, and they have stable, relatively small home ranges (200–1000 ha).
- Dispersal is restricted by the availability of permanent fresh water to wallow in and drink.
- The Judas animal method (see Section 8.4.2) has been highly successful in locating residual buffalo.

3.2.3 Camels (*Camelus dromedarius*)

One-humped camels were first introduced into Australia in the 1840s to assist in the exploration of inland Australia. The current distribution of feral camels covers much of arid Australia; however, densities vary across this range. Camels tend to live in remote areas, with large population numbers centred in the Simpson and Great Sandy deserts (Saalfeld and Edwards 2008). As camel numbers and range have both expanded, camels have encroached more into remote communities, mainly in search of water during the hotter months (Saalfield and Edwards 2008).

Box 3.3 Key factors — camels

Factors that increase the risk of maintaining, transmitting and dispersing diseases

- During periods of drought, large numbers of feral camels (up to 500 animals) congregate near watering points, where they have been observed to interact with domestic livestock.
- Camels can travel great distances (50–70 km per day and up to 5500 km per year).
- They compromise the security of farmed animals (eg cattle) by damaging fences.

Factors that reduce the risk

- Generally, feral camel populations have relatively low densities; however, in some areas of the Simpson Desert, they may have higher densities.
- The dog fence provides a significant deterrent to the movement of camels into what is probably highly suitable habitat on the other side.
- Camels inhabit very remote areas, away from human settlements, which, conversely, may make any control operation(s) more difficult.

3.2.4 Cats (*Felis catus*)

Moodie (1995) defines feral and stray cats as follows:

- *Feral cat*. A free-living cat that has minimal or no reliance on humans, surviving and reproducing in self-perpetuating populations.
- *Stray cat*. A cat that relies on humans for some of its ecological requirements.

Feral cats are distributed Australia-wide in most terrestrial habitats. They are a highly adaptable species, and few environmental factors limit their distribution in Australia (Dickman 1996). Cats are implicated in a number of zoonotic diseases (Robertson 2008), of which rabies is of most concern. Although no unique rabies variants are associated with cats, they are the principal source of infection for humans in some countries (Bunn 1991). In the United States, feral cats were found to have no greater impact on transmissible diseases than free-roaming pet cats (Nutter et al 2004).

Box 3.4 Key factors — cats

Factors that increase the risk of maintaining, transmitting and dispersing diseases

- Feral cats are widely distributed across Australia and are highly cryptic.
- They are highly adaptable, and can survive and reproduce in nearly any habitat.
- The density of wild cats is often highest where they are associated with humans (stray cats).
- Cats have a high potential rate of increase (feral cats in southeastern mainland Australia have, on average, two litters per year), so maintaining low population densities will be expensive and require ongoing efforts.
- No feral cat control technique has been shown to be effective in substantially reducing numbers over a large area.
- Although the home range of a feral cat tends to be stable, movements and dispersal may contribute to disease spread. Movements include:
  - moving out to find prey and sometimes living commensally with people
  - exploratory or migratory movements
  - movement away from the natal home range (settling some 4–8 km away) by young males before breeding (other immature males may move in to take their place).

Factors that reduce the risk

- The home ranges of urban stray cats tend not to overlap.
- Restricting the movements of urban cats at night would reduce the likelihood of their contact with wild animals.
- Feral cats are largely solitary animals.
- They tend not to move great distances and have stable, relatively small home ranges.

3.2.5 Cattle (*Bos taurus* and *Bos indicus*)

Feral European cattle (*Bos taurus*), zebu cattle (*Bos indicus*) and their hybrids have formed wild populations. These are largely limited to northern Australia, where they live in many rugged and remote areas where it is difficult to muster. Feral cattle often live in areas where domestic animals have been allowed to free range (Strahan 1995). These cattle do not remain wild for long. Once they are known to exist, they are captured or killed for economic or disease-control purposes. They are neither widespread nor abundant.

Box 3.5 Key factors — cattle

Factors that increase the risk of maintaining, transmitting and dispersing diseases

- Feral cattle share the same pathogens as domestic cattle and may interact with domestic stock.
- They are usually located in inaccessible terrain.
- Apart from bulls, they are gregarious, tending to run in groups (10–30 animals in northern Australia).
- They have a wary and skittish temperament.

Factors that reduce the risk

- Due to their economic value, feral cattle populations are neither widespread nor abundant; they are largely limited to northern Australia.
- They are usually easily detected, mustered, and captured or killed.

Note: Banteng cattle have only a limited and remote distribution on the Cobourg Peninsula in the Northern Territory. Nevertheless, outbreaks of screw-worm fly, an insect-borne virus, or any disease readily transmitted between banteng and horses or pigs would constitute a significant threat.

3.2.6 Deer

There are six main species of feral or wild deer in Australia: chital (*Axis axis*), sambar (*Cervus unicolor*), rusa (*Cervus timorensis*), hog (*Axis porcinus*), red (*Cervus elaphus*) and fallow (*Dama dama*). Currently, these species occur over much of Australia, except in semiarid and arid areas. Some species of deer are present in all states and territories, whereas others (eg hog deer) are found in only some states.

Some species are found in small, fragmented colonies in isolated areas. Individually and collectively, the distribution of these species is much more restricted than those of the other feral herbivores, but in recent years their range and numbers have been increasing (Moriarty 2004b). Some species such as sambar deer, in the highlands of Victoria, can be seasonally widespread and abundant. Red and fallow deer can be widespread over parts of the southeast region of South Australia.

Box 3.6 Key factors — deer

Factors that increase the risk of maintaining, transmitting and dispersing diseases

- Feral deer are gregarious (with the exception of sambar and hog deer); some species can form large groups of up to 100 animals. This can increase the probability of disease spread and may mean that deer could have a role in an EAD outbreak.
- Deer travel long distances and have cryptic behaviour.
- Their ability to become nocturnal in response to human disturbance makes control more difficult.
- They often live in rugged, inaccessible terrain, which makes aerial and ground shooting difficult.
- Deer have no natural predators other than man, and to a smaller degree dingoes and wild dogs.

Factors that reduce the risk

- The distribution of some species of feral deer is limited to small, localised populations. In these cases, deer are unlikely to play an important role in an EAD outbreak (note that this does not apply to all species).
- Sambar and hog deer, in particular, are solitary or live in small groups.
- Dispersal of deer is limited by hunting pressure and lack of suitable habitat.

3.2.7 Dogs (*Canis lupus dingo* and *Canis lupus familiaris*)

Wild dogs can be separated into three groups: the dingo (*Canis lupus dingo*), the wild domestic dog (*Canis lupus familiaris*) and the hybrid of these two. They can be found throughout Australia; however, purebred dingoes are found in the northern part of Australia, with hybrid dogs on the southeast coast and in the southwestern corner (Corbett 1995, Fleming et al 2001). Wild domestic dogs are most commonly found near towns and cities. Along with stray urban dogs, they may play a role in the spread of canine rabies. Dingoes are now listed as threatened under Victorian legislation.

Box 3.7 Key factors — dogs

Factors that increase the risk of maintaining, transmitting and dispersing diseases, particularly canine rabies

- Wild dogs are widespread. Of particular concern are populations on the outskirts of towns and cities that are in contact with humans and domestic stock.
- Urban stray dogs on the outskirts of towns make frequent or sporadic forays into the surrounding bush and countryside, which could provide a link between urban and wild animals.
- Wild dogs have a potentially high rate of increase because they can breed at all times of the year in cooler temperate climates (eastern highlands) and produce up to two litters of 4–5 pups per year.
- They form packs or groups, which increases the risk of disease transmission between the animals.
- Dingoes disperse when food availability is limited, potentially spreading disease over large areas. This may also occur with other types of wild dogs.
- There is the potential for rapid re-invasion of an area by wild dogs following intensive population control activities.

Factors that reduce the risk

- High temperatures, and lack of water or prey in many parts of Australia restrict the breeding and distribution of wild dogs.
- Dingoes in packs have relatively stable territorial boundaries, so protection of areas using buffer zones is a viable option (dingoes foraying out of their territory or range are rare).
- The presence of natural (escarpment) and constructed (dingo fencing) barriers limits dispersal of wild dogs.

3.2.8 Donkeys (*Equus asinus*)

Donkeys were imported into Australia in the 19th century. They were particularly useful in the northern regions of Western Australia and the Northern Territory, where they replaced horses affected by a toxic plant. Feral donkeys occur predominantly in arid or semiarid areas in northern Western Australia, the Northern Territory and northern South Australia, and in isolated pockets of Queensland and New South Wales (Northern Territory Government 2007, Woolnough et al 2005).

Box 3.8 Key factors — donkeys

Factors that increase the risk of maintaining, transmitting and dispersing diseases

- Feral donkeys are widely distributed over pastoral districts in the Northern Territory and Western Australia, and in scattered locations in South Australia and Queensland, where they are considered to be an agricultural and environmental pest.
- They have a relatively high reproductive potential, regardless of food availability, although survival of foals is greatly reduced when food is limited.
- They are able to survive dry periods better than other ungulates, tolerating exposure to high temperatures and the absence of surface water.
- They are not territorial, but have a social nature and will associate with stock. They have a habit of congregating in large groups of up to 500 animals around residual waterholes during the dry season.

Factors that reduce the risk

- Although feral donkeys are widely distributed, they tend to be found only in remote locations.
- The use of the Judas donkey technique (see Section 8.4.2) is very successful in locating residual animals.

3.2.9 Foxes (*Vulpes vulpes*)

Foxes have become widely established across the Australian mainland, with the exception of the wet tropics, and have made some incursions into Tasmania (Saunders et al 2006, Saunders and McLeod 2007). Their distribution appears to be limited in some, but not all, areas by the presence of dingoes and the absence of rabbits (Saunders et al 1995). Their northernmost limits tend not to be continuous and change with seasonal conditions, although some northerly movements are becoming permanent (Edwards et al 2004).

Box 3.9 Key factors — foxes

Factors that increase the risk of maintaining, transmitting and dispersing disease

- Foxes are widely distributed throughout the southern half of Australia.
- Their high densities in urban habitats bring them into contact with humans and domestic animals.
- They form family groups where food and other resources are abundant, which favours disease transmission.
- Subadult foxes, particularly males, disperse between late summer and the onset of breeding in winter, with two distinct phases of movement: a sudden, quick movement involving straight-line travel, followed by slower, less directed movements that persist until new territories are established.
- Foxes can disperse over long distances (up to 300 km for adult males).
- Foxes are scavengers and hunters, and therefore are susceptible to infection through feeding on dead infected animals.
- Surveillance and control operations may be difficult because:
  - density estimates of foxes are often difficult to obtain and may be inaccurate, due to the nocturnal and elusive nature of the fox and cyclic changes in foxes' density
  - foxes' variable behaviour and home ranges invalidate extrapolations from one area to another, and necessitate careful planning for specific areas
  - there is continuous distribution in most areas
  - there is rapid re-invasion of an area following intensive control operations
  - bait shyness may occur in populations in areas that are regularly baited.

Factors that reduce the risk

- The risk of a fox-adapted strain of rabies entering Australia is very low.
- Foxes do not appear to leave their home ranges in response to intense control activities.
- Although fox densities are higher in urban areas, the home ranges of urban foxes are smaller than those in rural areas.

3.2.10 Goats (*Capra hircus*)

Feral goats occur across Australia and on many offshore islands. They occur in all states and territories, but are most prevalent in the semiarid pastoral areas of Queensland, New South Wales, South Australia and Western Australia. Goats prefer hilly or scrubby areas for protection; however, their numbers are limited by food availability, water availability, predation and disease, either alone or in combination (Parkes et al 1996).

Box 3.10 Key factors — goats

Factors that increase the risk of maintaining, transmitting and dispersing diseases

- Feral goats breed year-round where food and water are abundant.
- The large size of their groups (up to 1000 animals observed) increases the probability of disease spread.
- Their large home ranges (up to 400 km^2 for males and 200 km^2 for females) and ability to move large distances (up to 30 km in 6 weeks in arid areas) mean that control areas for feral goats would have to be large.
- Feral goats move readily through most stock fences, making containment difficult.
- They sometimes intermingle with sheep while grazing and at water, which facilitates disease spread between the species.
- Control and containment of disease may be difficult, as control operations may cause goats to become wary and move to inaccessible areas.
- The enormous variation in feral goat densities, both between and within regions, further compounds difficulties for survey and control operations.

Factors that reduce the risk

- Populations of feral goats can be quickly reduced by a concerted mustering effort.
- Dispersal is limited by access to water, and by interaction with dingoes, dogs or humans.
- The Judas goat method (see Section 8.4.2) has been effective for locating and removing recalcitrant goats.

3.2.11 Horses (*Equus caballus*)

Feral horses are widely distributed in arid and semiarid parts of the Northern Territory, Queensland, South Australia and the northern rangelands of Western Australia. There are isolated populations in rugged areas in New South Wales and Victoria, with occasional incursions into the Australian Capital Territory (Dobbie et al 1993, Dawson et al 2006).

Box 3.11 Key factors — horses

Factors that increase the risk of maintaining, transmitting and dispersing diseases

- Feral horses are widely distributed, particularly in northern Australia, and their habitat overlaps with cattle habitat.
- They live in overlapping home ranges, in harems or bachelor groups, and their congregation in large cross-social groups of up to 100 animals to share food and water resources would increase the probability of disease spread.
- They move large distances (up to 50 km from water to feed) and hence have the potential to spread disease over large areas.
- They use hilly country to escape capture, which may hamper control operations; there may be difficulties removing residual animals that have become wary after being shot at during control operations.

Factors that reduce the risk

- Feral horses tend not to be found where domestic horses are kept.
- They have a low reproductive capacity, and mares generally have only one foal every two years.
- They do not disperse under control pressure, and their distribution is limited by human habitation and access to permanent water.
- In drier areas, control operations can be centred on waterholes with a high degree of success.

3.2.12 Pigs (*Sus scrofa*)

Feral pigs are most abundant and widely distributed throughout a range of habitats in Queensland and New South Wales. They occur at lower densities throughout parts of the Northern Territory, the Australian Capital Territory, Victoria, South Australia and Western Australia. Small numbers are present on Flinders Island in Bass Strait and in the southeast of Tasmania. In inland and seasonally dry areas of Australia, feral pigs are restricted to the vicinity of watercourses and associated floodplains. Populations, however, are still spreading in the more forest-covered parts of eastern and southwestern Australia, where access to daily water and shelter is not limited (Choquenot et al 1996).

Box 3.12 Key factors — pigs

Factors that increase the risk of maintaining, transmitting and dispersing diseases

- Feral pigs are distributed over a wide range of habitats, including agricultural areas, where they mix with other feral and domestic animals.
- They are scavengers, feeding on refuse and carcasses.
- They have a potentially high rate of population growth where food, water and shelter are abundant (producing two weaned litters every 12–15 months, with an average of 5–6 piglets per litter), which means that reducing and maintaining low population densities will be difficult, expensive and ongoing.
- They are occasionally found in large groups, particularly in tropical Australia (groups of more than 100 animals have been observed around waterholes); the interaction between individuals from different litters early in life would facilitate disease transmission.
- The ability of boars to move great distances daily and over longer periods would facilitate disease spread.
- Pigs' wallowing habits may increase the probability of disease transmission to other species that drink from or share the wallows, especially buffalo. Wallows also create environments that favour insect breeding, which is important in vector-borne diseases.
- Feral pigs may become wary and nocturnal if they are subjected to intensive or prolonged disturbance. Under these circumstances, they may shift home range or disperse over large distances to remote areas, thereby complicating control and containment operations.

Factors that reduce the risk

- Restricted access to water and shelter, particularly in hot environments, limits dispersal.
- Effective control techniques for pigs are well established, given sufficient time and resources.
- The Judas animal method (see Section 8.4.2) may be successful with recalcitrant pigs.

3.2.13 Wild birds

Wild bird populations can act as reservoirs for a number of viral and other wildlife diseases. In many cases, birds show no clinical signs of the disease and are relatively unaffected (eg low pathogenic avian influenza [LPAI], equine encephalomyelitis), but they can range through varying degrees of susceptibility from mild signs to severe signs and death (eg West Nile encephalitis, avian malaria). Some families of birds are more prone to certain diseases than others; for example, chlamydiosis is commonly more severe in Psittaciformes (parrots) and Columbiformes (pigeons), with most other bird species unaffected.

Wild birds, particularly Anseriformes (waterbirds such as ducks, geese and swans) and to a lesser extent Charadriiformes (shorebirds such as plovers, gulls, terns and oystercatchers), are known natural hosts for avian influenza viruses and have been implicated as a primary source of infection in outbreaks of highly pathogenic avian influenza (HPAI). Although HPAI viruses are not maintained by wild bird populations, the ability of circulating LPAI viruses to mutate into HPAI in poultry and other susceptible animals makes wild bird populations an important potential primary source of infection (Pfeiffer 2007, Stallknect and Brown 2007). There have been very few cases where wild bird hosts are implicated in the secondary spread of HPAI; this is usually associated with human activity, movements of infected poultry to markets and bird trade (Westbury 1998, Arzey 2004, Karesh et al 2007).

For more information on wild bird distribution, see the Birds Australia website.[6]

Box 3.13 Key factors — wild birds

Factors that increase the risk of maintaining, transmitting and dispersing diseases

- Wild birds in Australia are distributed over a wide range and have the potential to move large distances in relatively short periods of time. Many species are nomadic, moving large distances in response to drought or flooding (McCallum et al 2008).
- Many species, particularly shorebirds, annually migrate northwards, following recognised flyways throughout Asia.
- Waterbirds tend to congregate in large groups in wetland areas and around water bodies, increasing the potential for transmission between species. The presence of water is known to facilitate the transfer of some diseases between individuals.
- The disease status of many species of Australian birds is unknown, and broadscale surveillance is logistically difficult.

Factors that reduce the risk

- Outbreaks of diseases of concern that are carried by wild birds can result from either direct contact with domestic stock or contact with contaminated water — both preventable with good management techniques.
- Even though most Australian populations of Anseriformes (the major carrier of LPAI) are nomadic, they are not migratory, and their distribution is largely determined by available water bodies.
- There is a low prevalence of LPAI viruses in Australian birds (Tracey et al 2004, Haynes et al 2009)

6 www.birdata.com.au/homecontent.do

3.3 Distribution, density, home range and social organisation of wild animals

Tables 3.1, 3.2 and 3.3 summarise relevant characteristics of the main pest animal species in Australia. Data are not available for some attributes of some species.

Table 3.1 Biological and ecological attributes of feral herbivores

Attribute	Goat	Camel	Buffalo	Donkey	Horse	Cattle	Deer
Australian population (millions)	2.6[a]	1[d]	0.15[h]	> 1[k]	0.3–0.6[n]	0.1[s]	0.2[u]
Density (per km²)							Rusa
• average	5	0.29[d]	–	1[k]	1–2	0.25–1[t]	
• highest	26–98[b]	2[d]	–	10[l]	5.5[o]	–	40–60[v]
• lowest	0.5[a]		–	0.25[k]	0.05[p]	–	1–2[v]
Social organisation	Same-sex groups	Same-sex groups Older males solitary	Same-sex groups Older males solitary	Mixed herds	Same-sex groups	Single male with female herd[t]	Solitary or same-sex herds
Common group size	2–6[a]	2–6[a]	2–6[a]	Size unstable[m]	3–6[q]	–	Chital:[w] 20–40
Maximum group size	> 40[b]	500[e]	500[i]	–	Can join up to form large herds (>100)[n]	–	100
Home range (km²)	10–380[c] 1–4[b]	450–5000[f]	17–100[j]	3–32[m]	70–100[n]		Fallow: 6–9[x] Rusa: 1–8[v]
Movements	–	–	Seasonal	–	–	–	–
Daily (km/day)	–	1.5–4.4[f]	–	–	Up to 50[r]	–	–
Dispersal (km)	–	7000[g]	–	–	–	–	15[y]

– = data not available

Table notes continued on next page:

a Parkes et al 1996
b O'Brien 1984, Fleming 2004 (in high-rainfall areas in eastern Australia and on islands)
c King 1992, Freudenberger and Barber 1999 (in arid/semiarid areas, males larger than females)
d Saalfield and Edwards 2008
e Dorges and Heucke 1995
f Edwards et al 2001 (not clear if camels' movement is nomadic or within large home ranges)
g Grigg et al 1995
h S Garnett (pers comm in Albrecht et al 2009)
i Tulloch 1978
j Jesser et al 2008
k NRETA 2007a
l Choquenot 1988
m Johnson 2000
n Dobbie et al 1993
o Nesbitt 2006 (in eastern alps)
p Jennings 2006 (in arid areas)
q Walter and Hone 2003
r Berman 2006
s McKnight 1976 (difficult to estimate)
t NRETA 2007b
u Moriarty 2004b
v Moriarty 2004a (highest in cleared areas, lowest in forested areas)
w Groves and Bishop 1989
x Statham and Statham 1996
y Moriarty et al 2001

Table 3.2 Biological and ecological attributes of feral pigs

Attribute	Feral pigs
Australian population	–
Density (per km²)	
• highest (wetlands, swamps and floodplains)	1 to >20
• lowest (forests and semiarid regions)	0.1–4
Social organisation	
• common group size	1–10
• maximum group size (season dependent)	50–100
Home range (km²) — size affected by available food supply	
• male	1.4–43
• female	1.5–19.4
Movement (km)	
• temporary (subjected to disturbance/control activities)	5
• maximum	55

Source: Saunders and Bryant 1988
Note: See Choquenot et al (1996) for detailed information and references for across Australia.

Table 3.3 Biological and ecological attributes of feral cats, wild dogs and foxes

Attribute	Feral cats	Wild dogs	Foxes
Density (per km^2)	0.7–2.4[a]	Density related to food and water supply and human settlement[e]	Temperate: 4–7[gh]
• highest	10–15[b]		Urban: up to16[i]
• lowest	0.6–0.8[c]		Arid/forested: 0.2–2[g]
Social organisation		Highly flexible	
• common group size	Solitary	Family (3–12)	1 male, 1 female and cubs
• maximum group size	1 adult with young	Form packs to hunt large prey	1 male, several females and cubs
Home range (km^2)	0.1–6.2[abd]	10–300[e]	0.5–6.1[ghjk]
Movement			
• daily (km/day)	<2[c]	15[f]	<10[g]
• dispersal (km)	–	1–250[e]	Up to 300[j]

– = data not available
a Jones and Coman 1982 (in semiarid southeastern Australia)
b Page et al 1992 (in urban environment)
c Read and Bowen 2001 (in arid areas)
d Molsher et al 2005 (in central–western New South Wales)
e See Fleming et al 2001 for detailed information and Australian references
f Harden 1985
g Saunders et al 1995 (summary of studies)
h Saunders et al 2002
i Marks and Bloomfield 1999
j Meek and Saunders 2000
k White et al 2006

4 Principles of disease control

4.1 Introduction

This section aims to help disease controllers develop a plan of action to deal with an emergency animal disease (EAD) outbreak involving (or possibly involving) wild animals. It provides an overview of a systematic approach to the objectives, methodology and constraints of establishing disease status, conducting disease control and containment operations, and demonstrating disease freedom in wild animals.

4.2 Challenges wild animals present to disease controllers

Wild animals often live in areas where their control and containment are both difficult and expensive. Moreover, although rapid population knockdowns can be achieved (eg within 1–2 weeks), control and containment may take longer, and in some cases might prove impossible. Wild animals can often pass through fences designed for livestock, and their movements could frustrate attempts to contain or eliminate an EAD. Infected wild animals might evade attempts to contain and eliminate them, and they can disperse a considerable distance. Few elements in an EAD outbreak will be less tractable or predictable. In some cases, a disease may change the normal behaviour of wildlife. There should be no false expectations about the ability to control wild animal populations should they become involved in an EAD outbreak.

The susceptibility of most Australian native species to natural infection with many EADs remains untested. This Wild Animal Response Strategy concentrates mainly on introduced species (feral animals), but epidemiologists should be mindful of the possible involvement of native species in the epidemiology of an EAD.

4.3 Principles of disease control in wild animals

The first requirement is to ascertain which susceptible wild animal species are present in the area and whether infection is present in them. If disease is present, the initial aim should be to control or restrict those species that are most likely to transmit disease.

In the longer term, the existence of wild animal carriers or reservoirs of disease will make it more difficult to demonstrate disease eradication. Therefore, the long-term aim should be to eradicate disease from these species. This may necessitate local elimination of the entire population or, if this is not feasible, containment and reduction of the population to levels where infection is unlikely to persist. Increasing the population’s immunity by vaccination may also eliminate infectious agents or reduce the spread of infection. However, threshold densities for disease persistence in wild animal populations will rarely be known in advance, and where two or more susceptible species live in the same area (ie are sympatric), they might interact to lower the individual threshold density for each species.

In the case of rabies, the time taken to detect the development of disease in wild animals will be a determinant of the required control zone and probability of eradication. Techniques used against one or a number of sympatric susceptible species should avoid prejudicing operations directed at another. If only one of a pair of sympatric species is infected, operations should be conducted in such a way as to minimise the risk of disease spillover.

In any particular outbreak, the following subsections describe the steps to be followed. Not all the steps may be required, and they may be truncated or used in a different sequence. The selection of strategies and techniques will be determined using the decision-making key in Section 5. Also refer to Part B, 'Operational guidelines' of this manual.

Step 1 — Determine the distribution and density of susceptible wild animals

Obtain local knowledge of the distribution and habits of the wild animal species in the area. Where required, a wildlife biologist familiar with the species should also conduct appropriate surveys to obtain information on the abundance of wild animals. The survey area should encompass all animals likely to have been exposed to infection, based on available information. It is necessary to take account of home-range sizes, but also to consider that exceptional movements may have spread the disease further (information on species' home ranges is in Section 3). Natural barriers, topographical features and, where appropriate, watering points should also be taken into account. The population survey should avoid drawing in domestic stock.

Step 2 — Carry out disease surveillance in wild animals

The epidemiologist and wildlife biologist should, if appropriate, determine the area and intensity of disease sampling, following the population survey. In some situations (eg for species known to be fairly uniformly distributed over wide areas), sampling may begin before the population survey or be carried out at the same time. The aim is to determine whether infection has spread to wildlife and to obtain an indication of the extent of its spread.

Sampling techniques are described in Section 7 (see also the relevant **Disease Strategy**).

Step 3 — Contain wild animals that may transmit the disease

If disease is detected in wild animals, the primary aim is to stop infection spreading by preventing contact between animals in the infected area and the rest of the population.

A wild animal control area can be defined by surrounding the known extent of disease, based on the estimated rate of lateral spread of the disease and allowing for the incubation period of the disease. Techniques are defined in Section 9.

Containment may involve the use of natural barriers to restrict the inward and outward movements of people and animals. Outward movements risk disease dissemination, and inward movements seriously compromise the ability to demonstrate the effectiveness of depopulation and the absence of potential carrier species.

Containment may be impractical for diseases that involve insect vectors.

Step 4 — Control susceptible wild animals to eradicate disease and prevent its transmission

Eradicating the disease could entail the depopulation of some or all susceptible hosts within the wild animal control area. This would require the use of appropriate population-reduction techniques (see Section 8). Because of the possibility that control measures might cause dispersal, disease surveillance should be undertaken to allow early detection of any disease spread outside the wild animal control area.

This may involve rapidly destroying all susceptible and diseased animals within the wild animal control area to establish an animal-free zone. If rapid depopulation is not possible, disease spread may be stopped by starting depopulation in the outer margins of the wild animal control area. In some situations, disease eradication may involve either vaccination (eg for rabies control) or doing nothing (ie if the area is well contained, allowing the disease to run its course and die out naturally).

Step 5 — Demonstrate freedom from the disease

The state or territory chief veterinary officer, in conjunction with the Consultative Committee on Emergency Animal Diseases, will determine whether demonstration of freedom from the disease in wild animals is appropriate; if so, a wildlife biologist and epidemiologist will determine the most suitable methods to apply. Principles involved in demonstrating freedom from disease are considered further in Section 7. The most appropriate principles will depend on the type of disease (see the relevant **Disease Strategy**).

5 Decision-making key

5.1 Strategic planning

The decision-making key shown in Section 5.2 is a guide to the strategic planning needed for decision making for a response to an emergency animal disease (EAD) when wild animals may be implicated or pose a risk of disease transmission. The key should be used only after consultation between relevant personnel and should not be adopted by individuals. Subsequently, it may be used by an advisory group of animal health and wildlife/vertebrate pest technical experts to guide decision making on operations involving wild animal species.

There are four parts to the process, each with its own timescale:

- *risk assessment* — immediate to short term
- *surveillance* — short to medium term
- *operational decisions* — medium to long term
- *evaluation* — long term.

The checklist is not definitive; rather, it is a logical sequence that should be followed to its ultimate conclusion. There are various grey areas. Many of the operations and decisions may be concurrent, and they are often not mutually exclusive (eg population survey and disease sampling).

5.2 Decision-making key

Part A — Risk assessment

Steps 1 and 2 are immediate to short-term actions.

Step 1 Is there any reasonable probability of the disease occurring in wild animals?

When making this decision, consider reliable knowledge of factors such as known relationships between the disease and wild animals (based on worldwide data), and distribution of wild animals in the vicinity of the disease outbreak.

Yes	Go to step 2
No	Go to step 5
Do not know	Go to step 3

Step 2 Has a diagnosis of the disease been made in wild animal hosts?

Yes	Go to step 8
No	Go to step 5

Part B — Surveillance

Steps 3 to 8 are short- to medium-term actions.

Step 3 Determine the distribution and abundance of susceptible wild animal host species on the basis of local and other existing knowledge and, where deemed necessary, a reconnaissance of the area using an aerial or ground survey.

Based on survey results (numbers of wild animals, contact with domestic animals), are wild animals likely to pose a risk?

Yes	Go to step 4
No	Go to step 5

Step 4 Do we know if wild animals or domestic animals (or both) are infected?

Disease is thought to be present only in domestic animals	Go to step 5
Disease is thought to be present in domestic animals, with the status of wild animals unclear	Go to step 5
Disease is thought to be present in both wild animals and domestic animals	Go to step 5
Disease is thought to be present in wild animals, with the status of domestic animals unclear	Go to step 6
Disease is thought to be present only in wild animals	Go to step 6

Step 5 Should we ignore wild animals?

Consult with a vertebrate pest expert on the wild animal species implicated. Decide whether or not to take action against wild animals, taking into account the decision factors (Section 5.3).

The perceived or real consequences of inaction are of little importance	Go to step 14
Wildlife cannot be ignored	Go to step 6

Step 6 Sample wild animals for the presence of the disease agent

This process may be prolonged until adequate data are obtained. The time taken depends on circumstances and the consequences of a false positive or false negative.

Consult experts[7] to consider and, if appropriate, initiate the following:

- a detailed population survey, using decision factors (Section 5.3); and/or
- disease sampling.

See Part B, 'Operational guidelines', of this manual.

Disease is detected in wild animals	Go to step 8
No disease is detected in wild animals	Go to step 7

In some situations, consider conducting operational procedures concurrently with disease sampling.

[7] Consider establishing an advisory group of wild animal experts and epidemiologists. Also consider establishing a wild animal section at the local disease control centre.

Step 7 Relevance of wild animals

When the data are inadequate:

If disease control in domestic animals does not proceed as quickly as expected, consider increasing the intensity and range of testing of wild animals (where relevant)	Go to step 6
Wait for a period, taking into account the decision factors (Section 5.3)	Go to step 6
Consider whether to control and contain wild animals as a precautionary measure, taking into account the decision factors (Section 5.3)	Go to step 10

When the data are reliable and:

No disease is detected in wild animals during sampling	Go to step 14
Disease is detected in wild animals during sampling	Go to step 8

Part C — Operational decisions

Steps 8 to 11 are medium- to long-term actions. These steps are likely to continue simultaneously for a prolonged period.

Step 8 Select appropriate control or containment strategies (or both)

Disease has been detected in wild animals. Select the appropriate methods to contain and control wild animals or the disease, depending on all the decision factors (Section 5.3).

No targeted action against wild animals	Go to step 10
Nonlethal disease control measures, including vaccination	Go to step 11
Lethal disease control measures for wild animals and containment	Go to step 12

Step 9 Assess and review control and containment methods

Disease is still present in susceptible host	Go to step 5
Disease is no longer detected in susceptible hosts	Go to step 13

Note: Surveillance strategies, as outlined in step 6, will still be necessary, especially to determine the extent of infection.

Step 10 Continue to monitor wild animals

Continue to monitor wild animals for the presence of disease during and after domestic animal operations. The procedures will be developed in consultation with an advisory group of epidemiologists and species experts, who will refer to Part B, 'Operational guidelines', of this manual and the relevant **Disease Strategy**.

There is continuing or increasing concern over disease in wild animals	Go to step 8
There is insignificant or no concern about disease in wild animals	Go to step 13

Step 11 Nonlethal disease control measures for wild animals

Implement appropriate methods, including vaccination and nonlethal population control methods, taking into account the decision factors (Section 5.3). See Part B, 'Operational guidelines', of this manual and the relevant **Disease Strategy**.

Disease is still detected in susceptible hosts	Go to step 10
Disease is no longer detected in susceptible hosts	Go to step 13

Step 12 Lethal disease control measures and containment for wild animals

Implement appropriate methods to control and contain wild animals, taking into account the decision factors (Section 5.3). Refer also to Part B, 'Operational guidelines', of this manual and the relevant **Disease Strategy**. Control and containment methods will be modified depending on outcomes assessment.

Disease is no longer detected in wild animals	Go to step 13
Susceptible wild animal hosts are eradicated. It may be necessary to exclude wild animals from the wild animal control area until any remaining disease agent is inactivated.	Go to step 13
Wild animals are reduced below disease threshold level and disease is no longer detected	Go to step 13
Wild animal disease control operations fail to prevent expansion of outbreak, and disease is declared endemic	Go to step 15

Step 13 Monitor for residual disease

Disease is detected	Go to step 5
Disease is not detected	Go to step 15

Step 14 No action to be taken against wild animals

Periodically review the situation. Factors to consider in making this decision include the following:

- No wild animal species are present that are important in the maintenance and transmission of the disease.
- Any wild animals, even if infected, are unlikely to be a source of infection for domestic animals or people (or both).
- Any disease in wild animals will not persist after infection has been eliminated from domestic animals.
- The disease control in domestic animals (if commenced) is proceeding as expected.
- The action taken to test for the presence of disease in wild animals or to control wild animals is likely to have adverse consequences; for example
  - any dispersing of wild animals may further spread disease
  - wild animals may reinfect domestic animals
  - the actions may result in undue slowdown in disease control or other operations.

Developing concern	Go to step 5
No concern	Go to step 15

Step 15 Cease operations — no further action

The disease has been declared:

- endemic; or
- eradicated; or
- unresolved.

5.3 Decision factors

This section describes the factors that should be considered when deciding what action, if any, will be taken against wild animals. These factors are to be used in conjunction with Section 5.2 (the decision-making key). They will aid selection of the techniques or combination of techniques to be used for surveying, sampling, containing, and reducing or vaccinating wild animal populations. They are grouped under four headings:

- epidemiological factors;
- ecological factors;
- resource factors; and
- sociopolitical factors.

Some factors are relevant to more than one area and therefore appear under more than one heading.

5.3.1 Epidemiological factors

The threshold density (K_t) is the density necessary to maintain the disease in the wild. The aim of disease control is to reduce the number of susceptible animals to below this threshold. Strategies for disease control concentrate on reducing the rate of infection, usually by treating or reducing the number of infected individuals, or by preventing contact with susceptible individuals by vaccinating or reducing overall population density. Knowledge of the life history of a disease is essential for selecting the most appropriate technique for its control. The main epidemiological factors that need to be taken into consideration are shown below.

Transmission of the disease

Disease transmission across populations (horizontal transmission) can be either through direct contact (physical or infected discharges) or indirect contact via a vector (living or inanimate; mechanical or biological). Transmission between generations (vertical transmission) can be either hereditary or congenital. There are three main routes through which an infectious agent can gain entry to or leave a host — oral; respiratory; and through the skin, cornea and mucous membranes.

Three factors are important in the transmission of the disease (Thrusfield 2005):

- characteristics of the host(s), such as
  - susceptibility of the host species
  - infectiousness (ie ability to spread the pathogen)
  - incubation period of the pathogen in that particular species
  - typical mortality and morbidity
  - mobility of the species;
- characteristics of the pathogen(s), such as
  - infectivity
  - virulence
  - stability; and

- effective contact, including
  - mode of spread
  - rate of spread
  - behavioural changes
  - carrier status.

There are six common methods of disease transmission (Thrusfield 2005):

- ingestion;
- aerial transmission;
- contact;
- inoculation;
- iatrogenic transmission; and
- coitus.

All of these factors will have an effect on the type of operation. For example, with rabies, vaccination of susceptible wild animals may be a more effective option than population reduction, particularly if the disease appears to have been in the population for a considerable period.

Epidemiological importance of wild animals

The epidemiological importance of wild animals relates to:

- their potential role in spreading the disease to other animals (wild and domestic);
- their potential role in spreading the disease to people; and
- the persistence of the disease in wild animal populations after its elimination from domestic animals.

Density sought after control

The population reduction or vaccination coverage required will depend on the:

- disease;
- susceptible species present; and
- epidemiological situation.

Need for carcass, and carcass disposal

This could influence the choice of control method, as well as the decision to control wild animals or not. For more information on carcasses, see the **Disposal Manual**.

Control of the disease by vaccination or other nonfatal methods

This could depend on:

- the effectiveness of conventional control techniques; and
- the vaccine’s efficacy in wild animals, the availability of vaccine and authority to use it.

5.3.2 Ecological factors

Location

The topography, remoteness, ease of access and vegetation density will affect all operations, especially containment.

Season

The season will affect wild animal movement patterns, social behaviour, contact rates and drinking behaviour, as well as the ease of human access to the habitat.

Initial density of susceptible species

The higher the density of susceptible animals, the more likely disease is to spread. Also, the density of susceptible species will influence the techniques used. Different techniques may be employed sequentially as the animal density decreases.

Desired density sought after control

See Section 5.3.1.

Attainability of desired density

Whether or not the desired density can be attained depends on the species being controlled and other factors listed in this section. For example, it may not be possible to reduce feral pig populations to a predetermined or desired density in many habitats. Achieving target reductions to desired pig densities has proven difficult in full-scale simulated EAD exercises in Australia (Choquenot et al 1996).

Other susceptible species present in the same area

If two or more species are susceptible, the same technique should be used against all species, if possible. It is important not to use different techniques in the same area at the same time that may prejudice the effectiveness of each technique.

Likely movements of susceptible animals

Movement of wild animals might be altered by operations to survey, control or contain them. The likelihood of dispersal of wild animals will influence decisions about whether to intervene against wild animals at all, the techniques to use and the size of wild animal control areas.

5.3.3 Resource factors

Availability of resources

The availability of sufficient human and material resources to mount the operation needs to be considered.

There may have to be a compromise between the intensity of control and the area covered.

Attainability of target density

Attainability of target density can be related to the availability of resources and rate of response (see Section 5.3.2).

Need for carcass disposal

The ability to locate and dispose of carcasses will be resource dependent. This could influence the choice of control method, as well as the decision on whether to control wild animals (see the **Disposal Manual**).

Costs and benefits of different techniques

The relative capabilities and estimated costs of different survey, control and containment techniques will influence which ones are chosen.

Availability of expertise and knowledge

The availability and number of technical personnel (species experts, wildlife biologists) and operational resources (vertebrate pest control officers) could influence the scale and type of operation.

Availability of vaccine

The decision to vaccinate large numbers of wild animals will depend on whether vaccine is available in Australia or can be obtained in a reasonable time from overseas. The possible lack of information about efficacy and dosage of vaccines in wild species could also influence decision making.

Availability of distribution method for vaccines

It is likely that there will be minimal, if any, experience in the distribution of vaccine baits in Australia. However, there will be considerable experience in the delivery of toxic baits, the technology for which is transferable to vaccine baits. There will also be considerable expertise available from overseas, which should be drawn on as the need arises.

The impact of control measures against a particular species might need to be measured against the potential impact on other nontarget species.

5.3.4 Sociopolitical factors

Cost–benefit considerations

The cost of operations to control and contain wild animals should be less than the benefits they produce. An awareness of the costs of alternative operations, including inaction, will assist in the decision-making process.

Economy

The likely effect on the local, regional and national economies should be taken into account.

Attainability of desired density

See Section 5.3.2.

Legal ramifications

The relevant state or territory and national legislation, the likelihood of litigation, and the legal powers or licences required for control officers may influence the choice of strategy and techniques.

Public opinion

The decision to control wild animals, and the choice of control technique and carcass disposal could be influenced by public opinion.

Public safety

Concern for public safety could influence the choice to use certain control or capture methods, particularly in an urban area.

Occupational health and safety of operational staff

The choice of technique should take into account the health and safety of operational staff.

Government policy

The current state or territory and national policies on issues such as EADs, wild or feral animals, and rural assistance will influence the scale and type of operation.

Part B Operational guidelines

Part B of this manual provides operational guidelines that briefly describe procedures and techniques for:

- Section 6 — Population surveys.
- Section 7 — Disease sampling.
- Section 8 — Population reduction.
- Section 9 — Population containment.
- Section 10 — Multiple species operations.
- Section 11 — Management (role descriptions).

These sections provide guidelines only. When planning operations, it is essential to consult people with appropriate local knowledge and technical expertise. When implementing wild animal procedures, always consider the implications of externalities, such as animal welfare, occupational health and safety practices, the safe use of chemicals, environmental contamination, effects on nontarget animals, the presence of threatened communities and the views of Indigenous owners. Also, in the planning stage, consider how information collected within each of these sections is to be managed, stored, interpreted and relayed to personnel in the local disease control centre. The preparation of regular formal situation reports is integral to this process.

6 Population surveys

6.1 General information

Estimates of wild animal density and distribution can be used with local knowledge to:

- identify whether wild animals pose a risk of disease transmission and the intensity of disease sampling required;
- plan an appropriate strategy for wild animals;
- determine the size, location and type of operation, and the resource requirements;
- assess the progress of an operation (ie the extent of population reduction or containment, or both); and
- demonstrate, if required, in conjunction with disease sampling, freedom from disease or minimal risk of disease transmission in wild animals.

The survey might only require collation of local knowledge. See www.feral.org.au for species-specific distribution maps (Lapidge et al 2004–present).

6.2 Planning the survey strategy

6.2.1 Determining the area to be surveyed

The area surveyed should be large enough to encompass all animals likely to have been exposed to infection, based on available information. Selection of areas to be surveyed should aim to provide the maximum information in the time available, taking into account the species ecology. Where the survey area initially determined is large, this may increase the time required for the survey and place excessive demands on available resources. In this case, the survey area should be reconsidered and the area may need to be decreased. Refer to Section 3 for notes on species ecology.

6.2.2 Small outbreak in domestic animals, with wild animals uninfected

If there is no evidence of infection in wild animals and the outbreak in domestic animals is small (much smaller than the largest home range of any susceptible wild animal present), the area surveyed should be circular, with a radius at least equal to the maximum likely length of the largest home range of any susceptible species present. This area should allow for the marked asymmetry of some home ranges and should be based on epidemiological considerations. For information on species home ranges, see Section 3. In the absence of this information, the radius should equal the incubation period of the disease multiplied by the likely daily rate of its spread (this information is unlikely to be known for Australian conditions). A noncircular survey area may be more appropriate if indicated by the terrain or by local knowledge of wild animals.

6.2.3 Large outbreak in domestic animals, with wild animals uninfected

For a larger outbreak in domestic animals only, the survey should include the infected premises and dangerous contact premises, and an area around them (likely to be noninfected) at least as wide as the radius described in Section 6.2.2.

6.2.4 Large outbreak in domestic animals, with wild animals possibly infected

If the disease has infected wild animals, estimate the area likely to be infected from the maximum likely rate of disease spread and the length of time the disease is thought to have been present in wild animals. The surveyed area should then include this area and a buffer area of a width similar to that given in Section 6.2.2.

6.2.5 Wild animals infected

Where disease is present in wild animals, the surveyed area should include the likely limits of spread. How long the disease has been in Australia or whether the cases detected are the index cases will probably be unknown. Therefore, estimate the survey area by surrounding the known extent of disease with a buffer area, the width of which is based on the disease's incubation period and estimated rate of lateral spread. For example, the zone might need to be widened to allow for animal movement. The likely rate of spread should be estimated by the epidemiologist and a wildlife biologist, who should both be familiar with the relevant species, if possible. Surveying may be simplified and followed by a later, more detailed survey.

6.2.6 Population assessment teams

Population assessment teams should generally consist of:

- local vertebrate pest control or wildlife officers (or both), where possible; and
- at least one officer experienced in wild animal survey techniques.

If the workload is high, consider including a technical assistant(s) to assist with counting, data recording and mapping.

Population assessment teams will be briefed at the local disease control centre (LDCC) or forward command post (FCP) about where each team is to operate, what to look for, what techniques to use, and procedures for reporting, data recording and decontamination. Teams will report to the wild animal control and surveillance coordinator (see Section 11 for descriptions of these roles).

Population assessment teams will:

- complete a wild animal sampling form (see example in Appendix 2), which will clearly show the location and number of animals sighted (alternatively, they can use audited field notebooks); all new information will be entered into a centralised database each day;
- use a global positioning system (GPS) to accurately record the distribution and density of wild animals; and
- ensure that the mapping officer records the location of animals on topographic maps at the LDCC.

6.2.7 Techniques and species-specific information

The choice of technique will influence the accuracy of survey data (see Table 6.1).

Animal density can be measured in three ways (Caughley 1977):

- as the number of animals in a population;
- as the number of animals per unit of area (absolute density); and
- as the density of one population relative to that of another (relative density).

Techniques to survey populations of wild animals are the same for many species. For example, aerial survey is the most rapid and preferred method for feral herbivores and feral pigs where the vegetation is relatively open, or where the terrain is inaccessible or rough. Ground survey techniques, such as track and dung counts, are more appropriate for species such as dogs and feral pigs in closed forest. In many situations, only estimates of relative density will be possible. For information on species-specific techniques, consult wild animal species experts or wildlife biologists. The Mitchell and Balogh (2007) publications are useful references.[8]

The wild animal control and surveillance coordinator (see Section 11) and the epidemiologist should consult with an experienced wildlife biologist, who will be responsible for developing and conducting a rapid survey (where possible) to suit the prevailing conditions and availability of resources. The wildlife biologist will be competent in the statistical design and analysis of population surveys for the relevant wild animal species.

[8] www.dpi.nsw.gov.au/agriculture/pests-weeds/vertebrate-pests/general/monitoring-techniques

Table 6.1 Survey techniques for distribution and abundance of wild animals

Technique	Species	Comments
Aerial survey: • helicopter • fixed-wing plane	Buffalo, camel, cattle, deer, donkey, goat, horse, pig, waterbirds	Various methods available (eg strip transect, double count, total count) Needs experienced personnel Ability to sight animals is affected by habitat, group size, weather and time of day
Ground survey:		
• spotlight and day counts	All species (variable) Depends on nocturnal or diurnal behaviour	Highly variable outcomes and accuracy Requires time (which varies by species) Only to be used together with population reduction or disease sampling, or where other methods cannot be used
• trapping	All species (including rodents, wild birds, bats)	Dependent on habitat, vehicle access, species, previous control history (eg shooting makes animals wary of spotlights) All habitats in area need to be sampled Use line transect methodology wherever possible
• sign	All species	Various methodologies, including dung count; track count; den count; surveys of rooting, wallows and rub marks Initially, only use as a crude index and follow up with other methods
• free feeding	Most species (not well tested)	Select bait according to likely species and beware of nontarget take Requires time, and all habitats must be sampled Initially, only use as a crude index and follow up with other methods
Local knowledge	Most species	Consult land manager, local pest management authorities, survey information on pest animal distribution and local hunters, bushwalkers and so on

7 Disease sampling

7.1 General information

Early detection and determination of the wild animal species involved and the geographical extent of the disease are key requirements for managing an outbreak. Disease sampling is used to test for the presence and geographical extent of the disease in wild animal populations, and in some cases to give an indication of prevalence (ie the proportion of the population affected). At the end of an eradication campaign, sampling of wild animals may be required to prove freedom from the disease.

Disease sampling will involve gaining access to animals or faeces, and the use of a test to diagnose the disease. Obtaining animals or samples may involve:

- live capture techniques (eg trapping);
- lethal capture techniques (eg poisoning, shooting);
- sick animals encountered by hunters;
- observation of animals at feeding or trapping sites;
- fresh road kills; and
- carcass collection.

The test procedure may involve a simple inspection of animals for the presence of characteristic disease lesions, or collection of blood or other tissue samples. Isolation of the disease agent or antibody detection can be done with blood or tissue samples. Blood is one of the most common samples collected for diagnosing disease because serological testing (measurement of serum antibody) is one of the most commonly used diagnostic tests to discriminate between exposed and non-exposed animals.

The diagnostic methods to be used and the specimens to be collected will depend on the disease in question, and will be determined by animal health authorities at the time of the outbreak. Geering et al (1995) give details of recommended diagnostic samples and methods.

Sampling wild populations for evidence of disease poses several problems. First, the epidemiological formulae that are used to determine the required sample size to draw conclusions about the level of disease in a population rely on random sampling. In random sampling, all animals in the population have the same chance of being sampled. Clearly, with wild populations, the usual requirement for random sampling is unlikely to be met. Animals will vary in their 'sightability' and 'trapability' depending on biological factors such as age, size and behaviour, and on environmental factors such as terrain and habitat. Care must be exercised when drawing inferences about the prevalence of disease based on a sample of the wild animal population.

Second, many tests for sampling wild animals, particularly serological tests, will be directly transferred from domestic species and may not perform identically in wild animals. There may be differences in host responses, and wild species may be environmentally exposed to organisms with similar antigens that produce cross-reacting antibodies (Gardiner et al 1996).

7.2 Planning the sampling strategy

The sampling strategy to be adopted will depend on the objective of the sampling exercise. Three major reasons for sampling wild animals are:

- to test for the presence of the disease;
- to determine the extent of disease spread; and
- to prove freedom from the disease at the end of the eradication campaign.

The key issues that need to be considered are:

- how many animals need to be sampled;
- which areas should be sampled;
- how animals for sampling should be obtained;
- which samples are required; and
- how the findings should be interpreted.

The local disease control centre (LDCC) controller and epidemiologist, in consultation with the wild animal control coordinator or a species expert, will determine which wild animals to sample, which surveillance area to use, and the extent of sampling to be undertaken. The decision will be based on:

- type of disease;
- expected speed of spread;
- density and distribution of susceptible animals present;
- topography of the area;
- capability of diagnostic facilities;
- expected prevalence; and
- specificity and sensitivity of the test(s) available.

See Section 5 to ensure that all factors have been considered in the decision-making process. Appendix 1 lists sources that should be consulted when planning wild animal operations.

In consultation with local vertebrate pest control experts, the likely distribution of the wild animal species in the area should be determined (see Section 6). First, it should be determined whether the disease is present. Sampling should be concentrated on areas where animals are considered most likely to have come into contact with the disease (eg because there was likely contact with infected livestock or there are probable vectors). If it is quickly demonstrated that the disease is present in wild animals, a more extensive structured survey should be implemented.

Surveillance teams (see Section 7.5.1) will be allocated responsibility for specific areas. They will be responsible for examining animals and collecting samples.

7.3 Looking for evidence of disease in wild animals

The main purpose of disease sampling will be to determine if the wild animal population has been exposed to, or is harbouring, the disease agent. In setting the sample size, the following factors need to be considered:

- performance of the test procedure used;
- size of the population;
- prevalence of infection in the population; and
- extent of mixing in the population.

Tables (eg Cannon and Roe 1982) and various computer software packages (eg Epi Info, Win Episcope) are available for determining appropriate sample sizes, although, as discussed in Section 7.4.1, they rely on the assumption that random sampling is used. If population estimates are not accurate or cannot be readily obtained, then as many animals as possible should be captured and sampled, particularly in the vicinity of an infected premises (IP), and within and surrounding the restricted area (RA).

7.3.1 Is the disease present?

For managing emergency animal diseases, the key question is whether the disease is present in wild animals (see the decision-making key in Section 5). Random sampling is less important for answering this question than for other purposes. In fact, sampling should be targeted to maximise the chances of finding disease. This will involve preferentially sampling those animals with the highest risk of having come into contact with the disease. Depending on the disease in question, this may involve sampling and testing the following animals:

- those closest to a known IP;
- those downwind from an IP (if airborne spread is likely to be involved);
- those at locations (eg watering points) where they are likely to have come into contact with infected stock;
- if vectors are implicated in spread, those that occur where vectors are likely to be found (eg along watercourses); and
- those at 'highest' risk (eg bovines are considered indicator species for foot-and-mouth disease because of their extreme sensitivity to infection by the respiratory route).

Where the species is likely to be found in family or other social groupings, samples should be collected from all animals trapped or shot. It may be necessary to test only a few family or social members to be confident of finding disease.

7.3.2 Determining the extent of spread

Once the disease is found in a wild animal population, further information on the spatial extent of spread will be required to assess response options for setting RA boundaries and for implementing movement controls. Sampling should shift from targeting high-risk locations to a more structured and systematic approach aimed at determining the extent of spread. For example, animals could be sampled in a radial pattern at fixed distances from the known infected location (ie a concentric ring pattern). Alternatively, a grid could be overlaid on a map of the surrounding area and grid cells sampled according to a predetermined, systematic or random pattern. Sampling efforts should be concentrated in areas of known or preferred habitat for the species being investigated.

7.3.3 Estimating disease prevalence

In some circumstances, it may be useful to estimate the level of disease in a population. This information can be used for assessing how long the disease has been present and for estimating how quickly it is spreading. The data can also be useful for modelling studies to predict the likely future course of events.

Prevalence can be estimated from sampling results (refer to the epidemiologist), although the reliability of the findings will be questionable unless formal random selection techniques were used.

7.3.4 Multispecies testing

Where more than one susceptible wild animal species is present, the disease status of all susceptible populations should be assessed, and sampling should be undertaken in a coordinated manner.

In the initial stages, when the objective is to look for evidence of the disease, particularly if resources are limited, it may be appropriate to concentrate on the species that has the greatest risk of having been exposed. The sampling strategy can then be adjusted according to the initial findings.

7.3.5 Repeated sampling and ongoing surveillance

Although initial sampling may provide information on the disease status of the population at that time, it is important to appreciate that disease is not static. Disease may be spreading (often rapidly) in domestic livestock, and an initially disease-free population or area may become infected. Ongoing surveillance of populations that have tested negative may be necessary for the duration of the outbreak. This could involve:

- repeated trapping and sampling of animals in the population (animals could be fitted with radio transmitters to help relocate them), and the use of Judas animals if appropriate (see Section 8.4.2); and
- use of sentinel animals (animals could be maintained in a central trap or pen, and monitored for development of the disease).

7.3.6 Detecting residual disease following depopulation

Following control activities, it may be desirable to test the residual population for disease. This could pose problems, since remaining animals may be very difficult to locate. Penned sentinel animals or closely monitored free-ranging Judas animals could be considered. Fitting Judas animals with two transmitters to guard against collar failure could be considered.

7.4 Proof of freedom from disease

At the end of the outbreak, it will be necessary for Australia to demonstrate that the disease is no longer present in its wild animal populations, by meeting requirements in the relevant chapter(s) of the World Organisation for Animal Health (OIE)

Terrestrial Animal Health Code.[9] For proving freedom from the disease, a wide-area survey (which could involve domestic animals) is required, rather than a focus on high-risk areas. Although a true random sample may be impossible, it is important to use a process that is as random as possible to select animals for testing.

One approach, advocated by the OIE for proving disease freedom, is based on random selection of map coordinates. Further information is contained in *Recommended Standards for Epidemiological Surveillance for Rinderpest* (OIE 1993a).

7.4.1 Sample size

The size of the sample required to be tested for demonstrating freedom depends on:

- the size of the population;
- the likely prevalence of the disease, if present;
- the reliability required of the conclusions (ie the confidence level); and
- the sensitivity of the test used.

The larger the sample, the greater the confidence in the results.

If the above variables are known or can be estimated, then tables (eg Cannon and Roe 1982) and various computer software packages (eg Epi Info and Win Episcope) can be used for determining sample size. Alternatively, the confidence level can be determined if a random proportion of animals in a population has been tested and no positives were found. To prove freedom from a disease, the OIE guidelines for diseases such as rinderpest and contagious bovine pleuropneumonia (OIE 1993ab) suggest that the sampling strategy for domestic stock should be designed to have a 95% confidence level for detecting the disease at a prevalence of 1% (see Cannon and Roe 1982).

Where the population distribution is not uniform, it may be necessary to stratify it into sections that have a similar risk of maintaining the disease. For wild animal populations, in most cases, stratification will be by geographical areas. This means that once the target sample size that will provide the desired level of confidence has been calculated, the actual number of samples required, by area, will be proportional to the estimated numbers of animals present in these areas.

7.5 Field aspects of disease sampling

In many situations, disease-sampling operations will be conducted as part of population surveys, and planning should be undertaken in a coordinated manner. Alternatively, the decision could be taken for a pre-emptive population reduction of wild animals in the vicinity of an outbreak, and therefore disease sampling operations would be undertaken as part of a control operation.

If aircraft are to be used for sampling operations, the location of the nearest landing site or helicopter base should be determined. It will be necessary to obtain approval from the Civil Aviation Safety Authority to carry firearms on aircraft.

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[9] www.oie.int/international-standard-setting/terrestrial-code/access-online

Surveillance teams will be briefed at the LDCC about where each team is to operate, what to look for, what samples are required, decontamination procedures and how to deal with carcasses.

7.5.1 Surveillance teams

Membership

Surveillance teams should generally consist of:

- one veterinary adviser, or officer trained in disease recognition and sample collection; and
- one officer experienced in wild animal capture and control procedures.

If the workload is high, a technical assistant(s) could be included to assist with counting, data recording and mapping.

Duties

Surveillance teams will:

- complete specimen collection forms, together with a wild animal sampling form (see example in Appendix 2), or use audited field notebooks and maps that show the location of sampling sites and carcasses;
- use a global positioning system (GPS) to record sampling sites more accurately;
- identify specimens individually, pack them in sealed bags or containers as directed, and deliver them to a designated collection point for dispatch to a diagnostic laboratory (check procedures for transport of disease samples); and
- ensure that the mapping officer records the location of animals sampled on topographic maps at the LDCC.

7.5.2 Specimen collection

The number and type of samples to be collected will be determined in consultation with animal health authorities. Detailed descriptions of sample collection methods, and specimen preparation and storage are beyond the scope of this document. For further information, see Geering et al (1995), the **Laboratory Preparedness Manual** and the relevant **Disease Strategy**.

Once samples are taken, carcasses should be treated or disposed of as directed by the LDCC (see the **Disposal Manual**).

7.6 Techniques for capturing animals

Techniques for capturing wild animals (Table 7.1) can be considered in two groups: those that return a live animal (live capture) and those that return a dead animal (lethal). Advantages and disadvantages of individual techniques are listed in Section 8.4.

Some of these techniques may cause animals to disperse. Alternative techniques that could be considered include:

- free feeding to facilitate good observations of animals for clinical signs;
- food trapping, which uses food as an attractant;
- collection of fresh road kills;

- collection of carcasses other than from road kills;
- by request, submission of sick animals found by hunters;
- tranquillising with dart gun; and
- examination of fresh faeces for the disease agent (see Section 7.7).

Consideration could also be given to slightly more disruptive Judas animal operations for large feral herbivores and feral pigs; water trapping for large feral herbivores; and sedation for all species.

The wild animal control and surveillance coordinator and the epidemiologist will consult with vertebrate pest control biologists and practitioners to determine the most appropriate techniques for the circumstances. A wildlife biologist experienced in the chosen technique must be consulted to design and evaluate the success of the operation.

7.7 Detection of disease in faeces

Detection of disease from environmental faecal sampling could be especially useful for rapid surveys of large areas, or when animals are particularly difficult to trap or shoot. This method will only be suitable for some diseases.

Table 7.1 Disease sampling techniques for wild animals

Technique	Species	Comments
Helicopter shooting	Buffalo, camels, cattle, deer, donkeys, goats, horses, pigs	The preferred method where samples are required quickly, and animals are not in heavy cover or grazing at night
Ground and spotlight shooting and hunting[a]	All species (including birds and bats)	For animals at permanent water or in heavy cover, nocturnal animals and carnivores Unlikely to be used for sampling feral pigs unless trapping is unsuccessful, or pigs to be sampled are those surviving trapping or poisoning campaigns[b] For birds, consider shooting at night with silenced rifles, using a red light for illumination
Shooting from a hide at feeding stations	Feral pigs	May be a valuable sampling technique
Trapping or netting[a] (mist and hand nets are also used for wild birds and bats)	All species (including rodents, birds and bats)	For long-term disease monitoring and sentinels. Only to be used: • together with population reduction • where other methods cannot be used • when there are small numbers • when birds are near water in hot weather
Mustering	Buffalo, camels, cattle, deer, donkeys, goats, horses	Consider using dogs
Judas animals	Buffalo, cattle, goats, pigs, camels, donkeys	For long-term disease monitoring and observations
Helicopter net guns	Deer, goats	Where live animals are required
Free feeding, food trapping, oral tranquillisation	Most species	Will facilitate observations of animals for clinical signs
Collecting fresh road kills	Cats, dogs, dingoes, foxes	Has been used overseas to facilitate detection of rabies
Observing sick animals (eg by hunters, bushwalkers)	All species (including birds and bats)	Has been used overseas to facilitate detection of rabies. An inducement or extensive media coverage may be necessary

a The type of equipment used (trap, gun, etc) will be species specific and determined by the wildlife biologist. See Sharp and Saunders (2005) for codes of practice and standard operating procedures.
b Wilson and Choquenot (1997)
Note: Refer to Section 8 for details of techniques and advantages and disadvantages; for example, bats, wild birds and rodents may need to be sampled.

8 Population reduction

8.1 Objective

Population reduction or depopulation of wild animals to a predetermined level can be used to minimise the risk of disease transmission (also see Section 7). If wild animals are considered to be a risk factor in the dissemination or persistence of infection, programs aimed at reducing contact between infected domestic animals, wild animals and uninfected susceptible domestic animals should be instigated as soon as possible. For further information on determining whether to instigate a population reduction program, follow the guidelines in Section 4.

In all disease situations, unrealistic expectations of wild animal control or depopulation operations must be avoided. Also consider that the removal of wild animals from an area may create a 'sink' into which healthy and infected animals may immigrate. Furthermore, aerial and ground shooting, hunting, shooting drives and inordinate numbers of control personnel in an area may cause unnatural dispersal of the wild animals and spread the disease. Many of the AUSVETPLAN disease strategies indicate that, in many instances, wild animals should be left alone and their control limited to activities that will not cause their dispersal. In particular, where wild animals are being infected by domestic animals, it is possible that, once this source is eliminated, infection may naturally die out in low-density wild animal populations. Another option is vaccination; for example, the trap–vaccinate–release program used for rabies in countries such as Canada.

8.2 Planning the control strategy

The local disease control centre (LDCC) controller, epidemiologist and wild animal control coordinator, together with appropriate species experts and local wildlife/vertebrate pest technical experts, will determine the type and extent of control operations to be undertaken (see Section 5; ensure that all factors have been considered in the decision-making process). Appendix 1 lists sources of information that should be consulted when planning wild animal operations.

The effectiveness of the techniques for reducing wild animal numbers will vary depending upon the species, density of the animals and the terrain. Many techniques (eg poisoning) can give relatively rapid knockdowns, but others such as trapping may take longer to reduce the populations to the desired level. However, it is usually best to use a coordinated approach, which may involve a range of techniques. Appropriate permits for the destruction of any native vertebrates must be obtained.

Consider the potential knock-on effects of control operations, such as the risk to nontarget species, the welfare of target and nontarget animals, and environmental contamination. Consider the sequential use of different techniques. Vary the technique(s) as the population density falls; the technique used first will depend on the starting density. Objectives and priorities for control operations should be set so that progress can be assessed. Areas where wild animals are infected, are suspected of being infected or have the greatest risk of contact with infected domestic animals should be preferentially targeted. Such an area is referred to as the wild animal control area.

Determining the population reduction required to achieve a threshold density at which disease will not be maintained or spread will be difficult when the dynamics of the disease can only be estimated and there is great variation in density between regions.

Disease sampling may be undertaken with population reduction to monitor the spread of the disease (see Section 7).

8.2.1 Control teams

Membership

Control teams should generally consist of:

- local vertebrate pest control or wildlife officers, where possible; and
- at least one officer (two is desirable) experienced in wild animal capture and control procedures.

If the workload is high, consider including a technical assistant(s) to assist with counting, data recording and mapping.

Briefing

Control teams will be briefed at the LDCC or FCP about where each team is to operate, what to look for, what techniques are to be used, procedures for reporting and data recording, decontamination procedures, and how to deal with carcasses. Teams will report to the wild animal control team leader, or the wild animal control and surveillance coordinator (or both; see Section 11 for role descriptions), depending on the size of the outbreak.

Duties

Control teams will:

- use safe and environmentally sound practices to humanely destroy target wild animals;
- complete a wild animal control form (see example in Appendix 3) or use audited field notebooks that will clearly show the location and number of animals destroyed, and the number of animals that escaped;
- use a global positioning system (GPS) to accurately record animals and the area of control; and
- ensure that the mapping officer records the location of animals destroyed on topographic maps at the LDCC.

Note: Carcasses should be treated or disposed of as directed by the LDCC (see the **Disposal Manual**).

Coordination of control efforts is critical to the success of any operation. Ensure that proper planning, recording of information and debriefing are carried out at all times.

8.3 Techniques and species-specific information

For further information on techniques relevant to a specific disease, refer to the relevant **Disease Strategy.**

Selection of technique will depend on:

- technique efficiency (ie the proportion of wild animals killed and how quickly given levels of reduction are achieved in the wild animal density);
- factors affecting the efficiency of the technique in different habitats;
- availability of carcasses for disease sampling; and
- effect of the technique on the movement and dispersal of wild animals from the wild animal control area (Wilson and Choquenot 1997).

Techniques specific to each species are presented in Table 8.1. It will be necessary to tabulate the performance targets achievable with each technique for each species, taking into account density, dispersal, ease of carcass disposal, use of available resources and cost.

If aircraft are used, it will be necessary to obtain approval from the Civil Aviation Safety Authority to carry firearms on board.

There is the potential for some control techniques (eg helicopter shooting of feral pigs) to cause changes in the behaviour of target populations. This may result in dispersal of surviving individuals. The likelihood of dispersal for deer caused by different control techniques is as follows, from highest to lowest: helicopter shooting, dogging, ground shooting, spotlight shooting, mustering, trapping, fencing, ground poisoning and aerial poisoning. The potential risk that dispersal may create for disease spread must be considered.

Table 8.1 Population reduction and disease control techniques for wild animals

Technique	Species	Comments
Lethal control		
Helicopter shooting	Buffalo, camels, cattle, donkeys, goats, horses, pigs	Rapid control with concurrent control of multiple species possible in open floodplain, grassland and swamp habitats, and in inaccessible or uneven terrain Not suitable in heavy cover May use Judas animals
Ground shooting	All species	Spotlight shooting for most species; from a hide for deer and birds May use Judas animals

Poisoning	Pigs, foxes, dogs, cats, rabbits	Achieved from ground or air (or both), depending on the habitat The following poisons are available[a]: • 1080 for all five species • yellow phosphorus and warfarin for pigs • cyanide for foxes • strychnine for wild dogs and foxes. Before using any poison, check legal status and conditions for use, as these may vary across Australia. Licensed, experienced wildlife/vertebrate pest technical experts must be used to mix and distribute baits
Fumigation	Foxes, rabbits	Not labour efficient; appropriate only during breeding season
Live capture		
Trapping[b]	All species	Trap at water, using lures, food or baits
Judas animals[c]	Buffalo, cattle, goats, donkeys, pigs, camels, some species of wild birds	Characteristics that make for the best Judas animals vary between species: • For cattle and buffalo, use young animals. • For goats, avoid extremes of age. Use both sexes. Eliminate unhelpful Judas animals, but persevere with at least some animals of both sexes for species where segregation of the sexes occurs. Although local animals are most suitable, it may be necessary to use disease-free animals from outside the area and introduce them in pairs or small groups. Replace animals and regularly test them for disease. Method has limited success with pigs
Mustering	Buffalo, camel, cattle, donkeys, goats, horses	Muster each species separately and minimise disturbance to other species Take care not to disperse animals; back up with shooters (usually in helicopters) to immediately destroy recalcitrant animals
Other		
Bait vaccination for rabies	Canids	Oral vaccination is effective and more desirable than population reduction because: • it is less disruptive to species population dynamics • foxes are generally resilient to population reduction methods
Urban control of rabies	Urban and stray dogs	‘Managed population’ and ‘immunised population’ approaches
Large-scale burning off	Buffalo, camels, cattle, deer, donkeys, goats, horses, pigs	Use only in exceptional circumstances
Small-scale burning off	Buffalo, feral cattle, horses	To produce green pick during dry season

Human sweep line	Buffalo, camels, cattle, deer, donkeys, goats, horses, foxes	Use only in exceptional circumstances
Sedatives	Goats, birds, fallow deer	Unproven for other species Alpha-chloralose has been used Diazepam used successfully in Tasmania

1080 = sodium monofluoroacetate
a Check state and territory legislation for regulations of use. Some poisons require a special permit. See Sharp and Saunders (2005) for codes of practice and standard operating procedures.
b Trap design differs between species; nets will also be used for wild birds and bats; a wildlife biologist or wildlife/vertebrate pest technical expert will design or advise on traps.
c See Henzell et al (1999) and Section 8.4.2 for information on Judas animals.

8.4 Capture and control techniques for wild animals

8.4.1 Lethal control techniques

Lethal control methods rely on shooting (helicopter or ground shooting) or poisoning. Codes of practice and standard operating procedures (Sharp and Saunders 2005) should be consulted for best-practice techniques and equipment requirements.

The following subsections detail the advantages and disadvantages of several lethal control techniques.

Helicopter shooting

During an outbreak, samples will be required early. Generally, the quickest retrieval method is recommended, and this is most commonly helicopter shooting.

Advantages

- Useful to obtain samples quickly.
- Can cover large areas rapidly.
- Large number of animals are controlled rapidly, with possible concurrent control of multiple species.
- Suitable for a wide range of larger species, such as horses, donkeys, cattle, buffalo, goats, camels, deer and pigs.
- Reduces mechanical disease spread by minimising ground contact.

Disadvantages

- Only suitable where vegetation density permits good visibility and where animals are not grazing at night.
- May cause dispersal (possibly mainly in high-density populations).
- Costly.
- There are few trained, accredited aerial marksmen, so they are likely to be a scarce resource.

Ground shooting

Advantages

- Can be used where terrain and vegetation cover preclude the use of helicopters.
- Spotlight shooting is suitable for nocturnal animals such as deer, foxes, cats and pigs.
- May be useful for follow-up surveys, particularly if animals have learned to hide.

Disadvantages

- Relatively slow and time-consuming compared with helicopter shooting.
- Will need many teams to cover large areas.

Poisoning

Routine poisoning of vertebrate pests (feral pigs, rabbits, wild dogs and foxes) is conducted throughout Australia using 1080 (sodium monofluoroacetate). This is carried out by government pest-management agencies in each state or territory, using similar methods. Other poisons such as warfarin (for pigs) and cyanide (for carnivores) are used under licence, mostly for research activities. In any instance where poisons are to be used in emergency animal disease control, local pest management agencies must be consulted. There are legal restrictions on who can mix and distribute baits, and how baits can be distributed.

This manual does not deal in detail with rodents and does not recommend widespread destruction of wild birds. Strict conditions apply to the use of poisons against these animals, and prospective users should consult state or territory departmental chemicals coordinators before using them.

Advantages

- Minimal disturbance.
- Can cover large areas quickly.
- Reduced risk of dispersal of animals.

Disadvantages

- Need to allow for a period of free feeding if poison baits are used.
- Nonspecific and may kill nontarget species.
- Unless a quick-acting poison, such as cyanide, is used, it may be difficult to locate carcasses.
- Efficacy is variable, particularly with 1080.
- It may be difficult to retrieve fresh tissue samples.

8.4.2 Live capture techniques

Live capture methods will generally involve some form of trap or snare. With larger animals, tranquilliser guns and oral tranquillisers in feed baits should be considered; net guns can be used for animals such as deer. Nets (mist and hand nets) are also useful for capturing wild birds and bats. Sharp and Saunders (2005) detail the best-practice techniques and equipment requirements in their codes of practice and standard operating procedures.

Trapping

Place traps close to suspected refuge areas, at permanent water, in association with barrier or temporary fencing, or along frequently used paths and pads. For traps at water, minimise dispersal by using separate one-way devices (ramps or spear gates) for entry and exit. Habituate the animals to using them and then close the exit device.

Note: Trapping is more likely to be effective when food or water is in short supply.

Advantages

- Minimal disturbance.
- Reduced risk of dispersal of animals.
- Live animals become available for use as sentinels or Judas animals.

Disadvantages

- May take a few weeks to achieve results.
- Need to allow a period for free feeding or familiarisation.

Judas animals

The Judas animal method uses animals carrying radio transmitters that are released into an area and join up with the local wild animals, allowing the entire group to be tracked. In Australia and on many island communities, the Judas animal method has been used successfully to control feral goats (Campbell and Donlan 2005). Techniques to improve the efficacy of this technique for goats, such as pregnancy termination, sterilisation and prolonged oestrus, have been investigated (Campbell et al 2005, 2007). This method proved highly cost-effective during the Brucellosis and Tuberculosis Eradication Campaign for cattle and buffalo in the Northern Territory (Carrick et al 1990, Robinson and Whitehead 2003). It has also been tested with feral pigs (McIlroy and Gifford 1997), donkeys (Woolnough et al 2005) and starlings (Woolnough et al 2006), and has been suggested for use with camels (Edwards et al 2001).

Judas animals that are obtained from among the population to be controlled are no more likely to disperse than any other members of the population. However, Judas animals obtained from elsewhere may be more likely to disperse. For this reason, Judas animals should preferably be obtained from within the restricted area, possibly at an early stage of the control operation, when they can be caught easily. If necessary, they could be held until eventual deployment. If dispersal does occur, Judas animals allow the dispersal to be readily monitored.

Advantages

- Judas operations minimise the disruption caused by human intervention in animal populations, and do not cause animals to disperse.
- The animals are cheap and, therefore, eradication is affordable in situations where it would not otherwise be contemplated.

- Population can be estimated from the numbers of Judas animals and wild animals seen.
- Free-ranging Judas animals can be used as sentinel animals, to test for the presence of residual or re-invading animals, and of disease — making them an ideal method of demonstrating freedom from disease at the end of a campaign.

Disadvantages

- Setting up Judas operations takes time and specialised equipment.
- It might take weeks or even months for a Judas animal to join up with a small population of target animals.
- Some radio transmitters fail, and Judas animals must be double-collared if it is essential that they be traced.

9 Population containment

9.1 Objective

Containment aims to prevent or minimise the risk of disease transmission by preventing infected or potentially infected animals making contact with disease- free animals. Containment may be achieved by:

- natural physical or environmental barriers (eg rivers, mountains, deserts);
- artificial barriers (eg fencing, bird-proofing); and
- surrounding the infected population with an 'animal-free zone' or a vaccinated wild animal control area.

Many of the AUSVETPLAN disease strategies indicate that improved fencing or bird-proofing around domestic animal industries will reduce the risk of disease-agent contact between domestic and wild animals.

When deciding whether to attempt containment, follow the guidelines in Section 4 and refer to the relevant **Disease Strategy**.

9.2 Planning the containment strategy

Appendix 1 lists sources of information that should be consulted when planning wild animal operations.

The local disease control centre (LDCC) controller, epidemiologist and wild animal control coordinator, in consultation with appropriate species experts and wildlife biologists, will determine the type and extent of containment operations to be undertaken.

A variety of techniques can be used to contain wild animals. The most important criteria for deciding if, or which, containment techniques are appropriate are:

- the nature of the disease;
- the availability of existing natural or human-made barriers;
- the timeframe available, as it may take some time to fully implement a containment strategy; and
- the availability of resources.

9.2.1 Containment teams

Membership

Containment teams should generally consist of:

- local vertebrate pest control or wildlife officers, where possible; and
- at least one officer experienced in wild animal capture and control procedures.

If the workload is high, consider including a technical assistant(s) to assist with counting, data recording and mapping.

Briefing

Containment teams will be briefed at the LDCC or FCP about where each team is to operate, what to look for, what techniques are to be used, procedures for reporting and data recording, decontamination procedures, and how to deal with carcasses. Teams will report to the wild animal control team leader, or wild animal control and surveillance coordinator (see Section 11 for role descriptions), depending on the size of the outbreak.

Duties

Containment teams will:

- establish and maintain physical barriers, if such barriers are used;
- use safe and environmentally sound practices to humanely destroy target wild animal species, ensuring that dispersal does not occur;
- complete a wild animal control form (see example in Appendix 3) or use an audited field notebook that will clearly show the location and number of animals destroyed and, importantly, the number of animals that escaped;
- immediately report the dispersal or escape of wild animals out of the wild animal control area;
- use a global positioning system (GPS) device to accurately record the area of operation within the wild animal control area; and
- ensure that the mapping officer records the location of animals destroyed on topographic maps at the LDCC.

Where feasible, carcasses should be treated or disposed of as directed by the LDCC (see the **Disposal Manual**). Note that, although the time and resources required to dispose of carcasses may compromise the speed of population containment, disposal may be necessary to ensure disease containment.

9.3 Techniques and species-specific information

Table 9.1 gives an outline of species-specific techniques.

Table 9.1 Containment techniques for wild animals

Technique	Species	Comments
Depopulation	All species	Use one or more of the techniques in Section 8 to create a buffer area around the wild animal control area or the infected area
Helicopter patrol	Buffalo, camels, cattle, deer, donkeys, goats, horses, pigs	Patrol the perimeter of the wild animal control area Clearing lines of vegetation may be useful
Fences[a]	All species	Expensive, resource intensive and inflexible Useful to contain a relatively undisturbed wild animal population while it is tested for disease presence, or while Judas animals are released and allowed to join up with local wild animals Most effective against small species; large herbivores, if agitated, will penetrate fences, so disturbances in the vicinity should be minimised For very large species, consider fences that alter dispersal paths and allow passage to be detected (eg electric fences that funnel buffalo to movement detectors)
Lure traps	Buffalo	Especially useful when oestrous females are baited in movement corridors Not successful for feral pigs
Cordon of armed personnel	Likely all species but not tested	Resource intensive and inflexible Use only when 100% containment is vital Combine with illumination

a Consult experts in feral animal and wildlife fencing
Note: Many of these techniques will be resource and time consuming.

10 Multiple-species operations

If operations are required against more than one species in an area, where possible, the chosen techniques should be applicable to all species. Operations are then likely to be less disruptive and quicker to apply, and enable more efficient use of resources. If this is not feasible, the techniques selected for one species should not compromise operations against others (see Tables 6.1, 7.1 and 8.1).

When resources are limited, those species with a demonstrated ability to amplify or spread the disease should be targeted first. Later, when the situation is under better control, the emphasis may be shifted to those species that can maintain the disease (ie are reservoirs of infection). Such a situation could arise, for example, in an outbreak of foot-and-mouth disease, where both feral pigs and feral goats may be infected. Pigs pose the greatest threat of spreading the disease to other animals and, where control operations are contemplated, it is logical to target pigs first because of their potential to excrete large amounts of virus.

In other situations, controlling infection in one species may be sufficient to bring the disease under control in the other species. This is frequently the case with rabies, where, although a range of species may be affected, only one species is usually responsible for maintaining the disease in an area.

In some situations, different types of operations may be considered against multiple species. For example, if two susceptible species are present in an area, but disease is present in only one, control operations may be directed at that species, while the other may be subjected to surveillance only. The situation should be kept under review.

A special problem arises where one species may feed on the carcasses of other species (eg feral pigs, foxes, wild dogs and dingoes). Where the former are at risk of becoming infected or of spreading disease, control operations that leave contaminated carcasses may be contraindicated. Alternatively, consideration may need to be given to disposing of or treating carcasses.

11 Role descriptions

The number of managers or coordinators required will depend on the scale of the outbreak and level of involvement of wild animals. Even if there is no-one dedicated to undertake these functions in a small outbreak, the functions still need to be carried out, either by someone in the local disease control centre (LDCC) with other management roles or by a wildlife officer who may also have other responsibilities.

As a guide, the different levels of outbreak are small scale, medium scale and extensive.

11.1 Small-scale outbreak

A wild animal control team leader will be appointed to the infected premises (IP) and may have the dual role of control and surveillance for the restricted area (RA). The responsibilities of this position are to:

- identify all important wild animals capable of spreading disease in the IP and dangerous contact premises (DCP) and, where appropriate, in the RA; and
- plan and coordinate an effective population reduction or containment program, disease surveillance program or population survey program to minimise the risk of disease transmission, by coordinating activities of field staff.

The main tasks are in the **Management Manual**, Control centres management, Part 2: Role descriptions (role IPRD-8).

Wild animal control experts may be appointed to the technical specialists unit within the Planning Section as required. Their responsibilities are to:

- develop an overall picture of the distribution, abundance and possible movement of wild animals throughout the RA, and possibly the control area; and
- provide advice on the potential for spread of disease by wild animals, the effect on the size of the RA and the need for disease surveillance.

11.2 Medium-scale outbreak

A wild animal control and surveillance coordinator will be appointed to the LDCC Operations Section. The responsibilities of this position are similar to those of the wild animal control team leader (see Section 11.1), with broader responsibilities beyond the IPs, including to:

- allocate or define operational areas; and
- coordinate and manage all wild animal control and surveillance activities within the RA and in any IPs or DCPs.

The main tasks are listed in the **Management Manual**, Control centres management, Part 2: Role descriptions (role LRD-OF2).

A wild animal control coordinator may also be appointed to the state or territory disease control headquarters (SDCHQ). For more information, see the **Management Manual**, Control centres management, Part 2: Role descriptions (role SRD-P6).

11.3 Extensive outbreak

In addition to the managers and coordinators listed in sections 11.1 and 11.2, a wild animal operations manager would be appointed to the LDCC Operations Section to manage and determine the effectiveness of all wild animal control and surveillance operations. The main tasks of this person are listed in the **Management Manual**, Control centres management, Part 2: Role descriptions (role LRD-OF1).

11.4 Structure of wildlife and coordinator roles

A basic structure of wildlife and coordinator roles is shown in Figure 11.1. This is a suggestion only; the actual structure will depend on the scale of the outbreak, as follows:

- A wild animal operations manager position (role description LRD-OF1) should be created for extensive outbreaks only.
- A wild animal control coordinator (SRD-P6) attached to the SDCHQ and the LDCC wild animal control and surveillance coordinator (LRD-OF2) may be necessary for medium- and small-scale outbreaks.
- A wild animal control and surveillance coordinator (LRD-OF2) may be required for a small-scale outbreak.

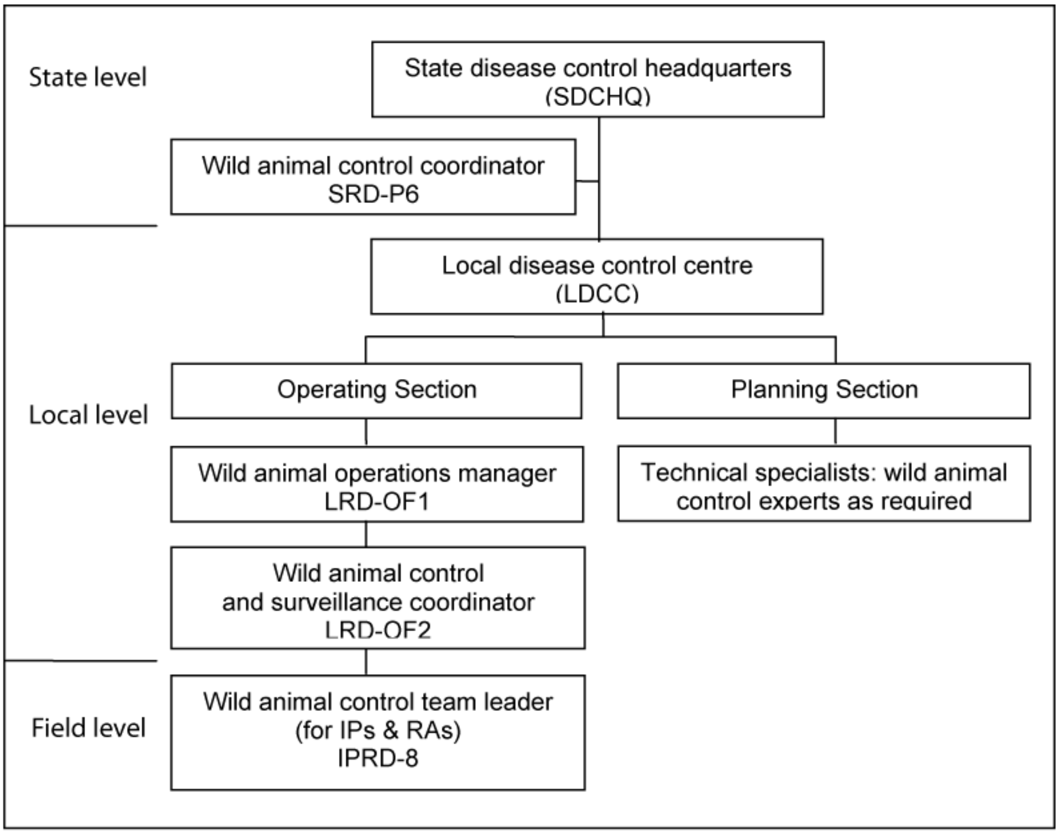

Figure 11.1 Organisational structure of wildlife manager and coordinator roles

Appendix 1 Sources of information

Species	Sources of information
All species	Consult local or state vertebrate pest control authorities[a] and control officers, national park rangers, landholders, local hunters and wildlife biologists to determine the likely location and density of species. Also refer to key documents.[bc]
Bats	Consult state government wildlife unit, museums, universities, carer groups.
Buffalo and cattle	Consult the most recent aerial surveys of the Northern Territory.
Camels	As for all species above. Consult most recent aerial survey data.
Deer	The Australian Deer Association Inc. and similar state bodies should be able to recommend hunters with local knowledge who can: • provide information on deer control and live capture; • evaluate deer numbers from tracks and spotlight counts; and • advise on feeding areas and seasonal movements. Also consult university researchers and the Australian Wildlife Management Society.
Dogs and dingoes	Consult local doggers and, where appropriate, the local or state authority responsible for wild dog destruction and university researchers.
Feral cats and foxes	As for all species above.
Feral goats	Consult commercial harvesters as to the location and number of goats shot and mustered in the area.
Feral horses and donkeys	As for all species above.
Feral pigs	Consult commercial harvesters and chiller operators as to the location and number of pigs shot in the area.
Marsupials	In addition to national park rangers, consult state government wildlife units, commercial harvesters, local field naturalists and wildlife conservation organisations.
Wild birds	Consult state government wildlife units, local and state ornithologist groups, Birds Australia and domestic bird producers as to the location and species of wild birds in the area, as well as Field and Game Australia, other hunting organisations and university researchers.

a Refer to the state or territory emergency disease management manual for contact details of organisations.
b Refer to www.feral.org.au for a list of key references for each species.
c Refer to www.wildlifehealth.org.au/AWHN/FactSheets/Fact_All.aspx for wildlife disease fact sheets.

Appendix 2 Wild animal sampling form (example)

Date					Operator name or ID			
Geographical area/zone					Location ID			
Animal ID	Location (GPS)	Time	Species	Age	Sex	Group size	Clinical signs	Sampled Y/N

Appendix 3 Wild animal control form (example)

Date	Operator name/ID

Geographical area/zone	Location ID

Operation type (circle)

Aerial shooting   Ground shooting   Baiting   Trapping   Other

Location (GPS)	Time	Species	Number in group	Number destroyed	Number escaped	Comments

Appendix 4 Relevant Australian legislation for disease and wild animal management

Authority	Name	Relevance
Commonwealth	*Exotic Animal Disease Control Act 1989* *Exotic Animal Disease Control Amendment Act 1995*	Prevention and control of outbreaks of animal diseases
	Agricultural and Veterinary Chemicals Code Act 1994	Control of agricultural and veterinary chemical products
	Environment Protection and Biodiversity Conservation Act 1999	Protection of environment and conservation of biodiversity
Australian Capital Territory	*Animal Diseases Act 2005*	Prevention and control of outbreaks of animal diseases
	Pest Plants and Animals Act 2005	Pest animal management
	Nature Conservation Act 1980	Conservation of native flora and fauna
	Environment Protection Act 1997	Regulate use of hazardous substances, coordinate environment protection
	Medicines, Poisons and Therapeutic Goods Act 2008	Regulate use of poisons
	Animal Welfare Act 1992	Trapping, handling and destruction of animals
	Firearms Act 1996 Firearms Regulation 2008	Regulate possession and use of firearms
	Work Safety Legislation Amendment Act 2009 (or equivalent)	Secure health, safety and welfare of employees at work
New South Wales	*Animal Diseases (Emergency Outbreaks) Act 1991*	Control of outbreaks of animal diseases
	Stock Diseases Act 1923	Management of disease in stock
	State Emergency and Rescue Management Act 1989	Emergency management
	Rural Lands Protection Act 1998 *Rural Lands Protection Amendment Act 2008*	Pest animal management on private and agricultural land
	National Parks and Wildlife Act 1974	Pest animal management on public land, non-native liberation
	Threatened Species Conservation Act 1995	Native flora and fauna conservation
	Pesticides Act 1999	Regulate use of pesticides and poisons
	Game and Feral Animal Control Act 2002	Regulate hunting of game animals and some pest species on public land
	Wild Dog Destruction Act 1921 Wild Dog Destruction Regulation 2009	Wild dog management in Western Division only
	Deer Act 2006	Regulate deer ownership
	Prevention of Cruelty to Animals Act 1979	Trapping, handling and destruction of animals
	Firearms Act 1996	Possession and use of firearms

	Firearms Regulation 2006	
	Occupational Health and Safety Act 2000	Safe working environment
	Stock Medicines Act 1989	Supply and use of stock medicines
Northern Territory	*Stock Diseases Act*	Detection, prevention and control of stock diseases
	Disasters Act	Emergency management
	Territory Parks and Wildlife Conservation Act 1998	Feral animal management, use of pesticides
	Poisons and Dangerous Drugs Act	Regulate supply and use of poisons
	Agricultural and Veterinary Chemicals (Control of Use) Act 2004	Regulate sale, use and application of chemical products
	Animal Welfare Act	Trapping, handling and destruction of animals
	Firearms Act	Regulate possession and use of firearms
	Workplace Health and Safety Act	Health and safety of workers
Queensland	*Exotic Diseases in Animals Act 1981*	Control of animal diseases
	Stock Act 1915	Stock disease management
	Disaster Management Act 2003	Emergency management
	Land Protection (Pest and Stock Route Management) Act 2002	Pest animal management
	Nature Conservation Act 1992	Conservation of nature
	Health Act 1937 Health (Drugs and Poisons) Regulation 1996	Regulate supply and use of poisons
	Animal Care and Protection Act 2001	Trapping, handling and destruction of animals
	Pest Management Act 2001	Protect public health from pest control and fumigation activities
	Weapons Act 1990	Possession and use of weapons, including firearms
	Workplace Health and Safety Act 1995	Protection in the workplace
South Australia	*Livestock Act 1997*	Regulate livestock matters, including exotic disease control
	Emergency Management Act 2004	Emergency management
	Natural Resources Management Act 2004	Pest animal management
	National Parks and Wildlife Act 1972	Conservation of wildlife
	Controlled Substances Act 1984 Controlled Substances (Poisons) Regulations 1996	Sale and use of poisons
	Animal Welfare Act 1985	Trapping and destruction of animals
	Dog Fence Act 1946	Wild dog management
	Firearms Act 1977	Control possession, use and sale of firearms
	Occupational Health, Safety and Welfare Act 1986	Health, safety and welfare of workers

Tasmania	*Animal Health Act 1995*	Prevention, detection and control of animal diseases
	Emergency Management Act 2006	Emergency management
	Vermin Control Act 2000	Pest animal management
	National Parks and Reserves Management Act 2002	Protection of national parks and wildlife against introduced species and diseases
	Nature Conservation Act 2002	Protection and conservation of native flora and fauna
	Poisons Act 1971	Regulate sale, supply and use of poisons
	Agricultural and Veterinary Chemical (Control of Use) Act 1995	Use and application of agricultural and veterinary chemical products
	Police Offences Act 1935	Illegal use of poisons
	Animal Welfare Act 1993	Use of traps and poisons, destruction of animals
	Firearms Act 1996	Regulation and control of firearms
	Workplace Health and Safety Act 1995	Health and safety of workers
Victoria	*Livestock Disease Control Act 1994*	Prevention, monitoring and control of livestock diseases
	Emergency Management Act 1986	Organisation of emergency management
	Catchment and Land Protection Act 1994	Pest animal management on public and private land
	Wildlife Act 1975	Wildlife protection and management
	Flora and Fauna Guarantee Act 1988	Management and control of native fauna and flora
	National Parks Act 1975	Management of natural environment in designated parks
	Agriculture and Veterinary Chemicals (Control of Use) Act 1992	Sale and use of poisons
	Drugs, Poisons and Controlled Substances Act 1981	Transportation of baits
	Prevention of Cruelty to Animals Act 1986	Trapping, handling and destruction of animals
	Firearms Act 1996	Regulation and use of firearms
	Control of Weapons Act 1990	Use of M44 ejectors
	Occupational Health and Safety Act 2004	Health, safety and welfare of workers
	Impounding of Livestock Act 1994	Impounding of livestock and regulation of impounded livestock
Western Australia	*Exotic Diseases of Animals Act 1993*	Prevention and control of exotic diseases
	Stock Diseases (Regulations) Act 1968	Prevention and control of diseases in livestock
	Biosecurity and Agriculture Management Act 2007	Control of declared pest or disease, use of chemicals

Agriculture and Related Resources Protection Act 1976	Pest animal management, control and prevention on agricultural land, regulate poison and trap use
Wildlife Conservation Act 1950	Protection of fauna and flora, illegal use of traps
Poisons Act 1964	Sale and use of poisons
Health Act 1911 Health (Pesticides) Regulations 2011	Use, storage and transport of certain pesticides
Animal Welfare Act 2002	Humane handling, and destruction and control techniques
Firearms Act 1973	Regulate use of firearms
Occupational Safety and Health Act 1984	Improve standards of occupational safety and health

Glossary

Animal byproducts
Products of animal origin that are not for consumption but are destined for industrial use (eg hides and skins, fur, wool, hair, feathers, hooves, bones, fertiliser).

Animal Health Committee
A committee comprising the CVOs of Australia and New Zealand, Australian state and territory CVOs, Animal Health Australia, and a CSIRO representative. The committee provides advice to PIMC on animal health matters, focusing on technical issues and regulatory policy (formerly called the Veterinary Committee).

See also Primary Industries Ministerial Council (PIMC)

Animal products
Meat, meat products and other products of animal origin (eg eggs, milk) for human consumption or for use in animal feedstuff.

Australian Chief Veterinary Officer
The nominated senior veterinarian in the Australian Government Department of Agriculture, Fisheries and Forestry who manages international animal health commitments and the Australian Government's response to an animal disease outbreak.

See also Chief veterinary officer (CVO)

AUSVETPLAN
*Aus*tralian *Vet*erinary Emergency *Plan*. A series of technical response plans that describe the proposed Australian approach to an emergency animal disease incident. The documents provide guidance based on sound analysis, linking policy, strategies, implementation, coordination and emergency-management plans.

Carrier
An animal recovered from a disease or not showing clinical signs, but capable of passing on the infection to another animal.

Chief veterinary officer (CVO)
The senior veterinarian of the animal health authority in each jurisdiction (national, state, territory) who has responsibility for animal disease control in that jurisdiction.

See also Australian Chief Veterinary Officer

Compensation
The sum of money paid by the government to an owner for stock that are destroyed and property that is compulsorily destroyed because of an emergency animal disease.

See also Cost-sharing arrangements, Emergency Animal Disease Response Agreement

Consultative Committee on Emergency Animal Diseases (CCEAD)	A committee of state or territory CVOs, representatives of CSIRO Livestock Industries and the relevant industries, and chaired by the Australian CVO. CCEAD convenes and consults when there is an animal disease emergency due to the introduction of an emergency animal disease of livestock, or other serious epizootic of Australian origin.
Containment	The process of containing a wild animal population within a defined area or buffer zone by the use of natural or artificial barriers and/or depopulation.
Control (wild animal)	The process of reducing either the population density of wild animals or the threshold density of the disease by lethal (eg poisoning, shooting) and nonlethal (eg trapping, vaccination) methods.
Cost-sharing arrangements	Arrangements agreed between governments (national and states/territories) and livestock industries for sharing the costs of emergency animal disease responses. *See also* Compensation, Emergency Animal Disease Response Agreement
Dangerous contact animal	A susceptible animal that has been designated as being exposed to other infected animals or potentially infectious products following tracing and epidemiological investigation.
Dangerous contact premises	A premises that contains a susceptible animal(s) not showing clinical signs but that, following a risk assessment, is considered highly likely to contain an infected animal(s) or contaminated animal products, wastes or things that present an unacceptable risk to the response if not addressed.
Declared area	A defined tract of land that is subjected to disease control restrictions under emergency animal disease legislation. Types of declared areas include *restricted area, control area, infected premises, dangerous contact premises* and *suspect premises*.
Decontamination	Includes all stages of cleaning and disinfection.
Depopulation	The removal of a host population from a particular area to control or prevent the spread of disease.
Destruction	The killing of an animal using an approved method during a disease response.
Disease agent	A general term for a transmissible organism or other factor that causes an infectious disease.

Disease Watch Hotline	24-hour freecall service for reporting suspected incidences of exotic diseases — **1800 675 888**.
Disinfectant	A chemical used to destroy disease agents outside a living animal.
Disinfection	The application, after thorough cleansing, of procedures intended to destroy the infectious or parasitic agents of animal diseases, including zoonoses; applies to premises, vehicles and different objects that may have been directly or indirectly contaminated.
Dispersal	Movements of animals (usually permanent migrations) outside their normal home-range area. Can be associated with annual reallocation of territory ownership (eg carnivores), search for resources or disturbance caused by control operations.
Disposal	Sanitary removal of animal carcasses, animal products, materials and wastes by burial, burning or some other process so as to prevent the spread of disease.
Emergency animal disease (EAD)	A disease that is (a) exotic to Australia or (b) a variant of an endemic disease or (c) a serious infectious disease of unknown or uncertain cause or (d) a severe outbreak of a known endemic disease, and that is considered to be of national significance with serious social or trade implications. *See also* Endemic animal disease, Exotic animal disease
Emergency Animal Disease Response Agreement	Agreement between the Australian and state/territory governments and livestock industries on the management of emergency animal disease responses. Provisions include funding mechanisms, the use of appropriately trained personnel and existing standards such as AUSVETPLAN. *See also* Compensation, Cost-sharing arrangements
Endemic animal disease	A disease affecting animals (which may include humans) that is known to occur in Australia. *See also* Emergency animal disease, Exotic animal disease
Enterprise	*See* Risk enterprise
Epidemiological investigation	An investigation to identify and qualify the risk factors associated with the disease. *See also* Veterinary investigation
Exotic animal disease	A disease affecting animals (which may include humans) that does not normally occur in Australia. *See also* Emergency animal disease, Endemic animal disease

Exotic fauna/feral animals	*See* Wild animals
Feral herbivores	Buffalo, cattle, camels, deer, donkeys, goats and horses are the large feral herbivores found in Australia.
Fomites	Inanimate objects (eg boots, clothing, equipment, instruments, vehicles, crates, packaging) that can carry an infectious disease agent and may spread the disease through mechanical transmission.
Home range	The area used by an animal in the course of its normal activities. Generally proportional in area to the amount of resources it contains (ie animals in a resource-rich environment have a smaller home range than the same species in a resource-poor environment).
In-contact animals	Animals that have had close contact with infected animals, such as noninfected animals in the same group as infected animals.
Incubation period	The period that elapses between the introduction of the pathogen into the animal and the first clinical signs of the disease.
Index case	The first or original case of the disease to be diagnosed in a disease outbreak on the index property. *See also* Index property
Index property	The property on which the first or original case (index case) in a disease outbreak is identified to have occurred. *See also* Index case
Infected premises	A defined area (which may be all or part of a property) in which an emergency disease meeting the case definition exists or is believed to exist, or in which the causative agent of that emergency disease exists or is believed to exist.
Judas animal	Animals carrying radio transmitters that are released into an area and join up with the local wild animals, allowing the entire group to be tracked.
Local disease control centre	An emergency operations centre responsible for the command and control of field operations in a defined area.
Monitoring	Routine collection of data for assessing the health status of a population. *See also* Surveillance
Movement control	Restrictions placed on the movement of animals, people and other things to prevent the spread of disease.

National management group (NMG)	A group established to direct and coordinate an animal disease emergency. NMGs may include the chief executive officers of the Australian Government and state or territory governments where the emergency occurs, industry representatives, the Australian CVO (and chief medical officer, if applicable) and the chairman of Animal Health Australia.
Native wildlife	*See* Wild animals
OIE Terrestrial Code	*OIE Terrestrial Animal Health Code.* Reviewed annually at the OIE General Meeting in May and published on the internet at: **www.oie.int/international-standard-setting/terrestrial-code/access-online/**
OIE Terrestrial Manual	*OIE Manual of Standards for Diagnostic Tests and Vaccines for Terrestrial Animals.* Describes standards for laboratory diagnostic tests and the production and control of biological products (principally vaccines). The current edition is published on the internet at: **www.oie.int/eng/normes/mmanual/a_summry.htm**
Operational procedures	Detailed instructions for carrying out specific disease control activities, such as disposal, destruction, decontamination and valuation.
Owner	Person responsible for a premises (includes an agent of the owner, such as a manager or other controlling officer).
Premises	A tract of land including its buildings, or a separate farm or facility that is maintained by a single set of services and personnel.
Prevalence	The proportion (or percentage) of animals in a particular population affected by a particular disease (or infection or positive antibody titre) at a given time.
Primary Industries Ministerial Council	The council of Australian national, state and territory and New Zealand ministers of agriculture that sets Australian and New Zealand agricultural policy (formerly the Agriculture and Resource Management Council of Australia and New Zealand). *See also* Animal Health Committee
Quarantine	Legal restrictions imposed on a place or a tract of land by the serving of a notice limiting access or egress of specified animals, persons or things.
Restricted area	A relatively small declared area (compared with a control area) around an infected premises that is subject to intense surveillance and movement controls.

Risk enterprise	A defined livestock or related enterprise, which is potentially a major source of infection for many other premises. Includes intensive piggeries, feedlots, abattoirs, knackeries, saleyards, calf scales, milk factories, tanneries, skin sheds, game meat establishments, cold stores, artificial insemination centres, veterinary laboratories and hospitals, road and rail freight depots, showgrounds, field days, weighbridges and garbage depots.
Sensitivity	The proportion of truly positive units that are correctly identified as positive by a test. *See also* Specificity
Sentinel animal	Animal of known health status that is monitored to detect the presence of a specific disease agent.
Serotype	A subgroup of microorganisms identified by the antigens carried (as determined by a serology test).
Specificity	The proportion of truly negative units that are correctly identified as negative by a test. *See also* Sensitivity
Stamping out	The strategy of eliminating infection from premises through the destruction of animals in accordance with the particular AUSVETPLAN manual, and in a manner that permits appropriate disposal of carcasses and decontamination of the site.
State or territory disease control headquarters	The emergency operations centre that directs the disease control operations to be undertaken in that state or territory.
Surveillance	A systematic program of investigation designed to establish the presence, extent or absence of a disease, or of infection or contamination with the causative organism. It includes the examination of animals for clinical signs, antibodies or the causative organism.
Survey (wild animal)	An investigation involving the collection of samples or information.
Susceptible animals	Animals that can be infected with a particular disease agent.

Suspect animal	An animal that may have been exposed to an emergency disease such that its quarantine and intensive surveillance, but not pre-emptive slaughter, is warranted. *or* An animal not known to have been exposed to a disease agent but showing clinical signs requiring differential diagnosis.
Suspect premises	Temporary classification of premises containing suspect animals. After rapid resolution of the status of the suspect animal(s) contained on it, a suspect premises is reclassified either as an infected premises (and appropriate disease-control measures taken) or as free from disease.
Sylvatic rabies	A cycle of rabies infection involving wildlife (derived from *sylvan* [adj] — pertaining to or inhabiting woods).
Sympatric species	Two or more species having common or overlapping geographical distributions.
Threshold density	Population density below which a disease dies out in a population.
Tracing	The process of locating animals, persons or other items that may be implicated in the spread of disease, so that appropriate action can be taken.
Vaccination	Inoculation of healthy individuals with weakened or attenuated strains of disease-causing agents to provide protection from disease.
Vaccine	Modified strains of disease-causing agents that, when inoculated, stimulate an immune response and provide protection from disease.
Vector	A living organism (frequently an arthropod) that transmits an infectious agent from one host to another. A *biological* vector is one in which the infectious agent must develop or multiply before becoming infective to a recipient host. A *mechanical* vector is one that transmits an infectious agent from one host to another but is not essential to the lifecycle of the agent.
Wildlife/vertebrate pest technical expert	An officer employed by a state or national authority who conducts operations to control noxious and feral animals (vertebrate pests); usually has excellent knowledge of the distribution and abundance of most species of wild animals within their location.

Veterinary investigation	An investigation of the diagnosis, pathology and epidemiology of the disease. *See also* Epidemiological investigation
Wild animal control area	An area in which wild animals are (or are suspected to be) infected with an emergency disease agent and have the greatest risk of contact with infected domestic stock.
Wild animals	
– native wildlife	Animals that are indigenous to Australia and may be susceptible to emergency animal diseases (eg bats, dingoes and marsupials).
– feral animals	Animals of domestic species that are not confined or under control (eg cats, horses, pigs).
– exotic fauna	Nondomestic animal species that are not indigenous to Australia (eg foxes).
Wildlife biologist	A specialist in the biology and ecology of one of a number of wild animals and/or vertebrate pests, who is competent in the design and analysis of population surveys.
Zoning	The process of defining, implementing and maintaining a disease-free or infected area in accordance with OIE guidelines, based on geopolitical and/or physical boundaries and surveillance, in order to facilitate disease control and/or trade.
Zoonosis	A disease of animals that can be transmitted to humans.

Abbreviations

AUSVETPLAN	Australian Veterinary Emergency Plan
CVO	chief veterinary officer
DCP	dangerous contact premises
EAD	emergency animal disease
FCP	forward command post
GPS	global positioning system
IP	infected premises
LDCC	local disease control centre
OIE	World Organisation for Animal Health
RA	restricted area
SDCHQ	state or territory disease control headquarters

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