AUSTRALIAN VETERINARY EMERGENCY PLAN

AUSVETPLAN

Wild Animal Response Strategy

Version 3.2, 2005

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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AUSVETPLAN is available on the internet at:
http://www.aahc.com.au/ausvetplan/index.htm

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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 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, or PIMC) out of session in December 1999 and was updated in 2005 to take account of recommendations from the exercise 'Wild Thing', which was held in northern Queensland in 2003.

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.

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:

Disease strategies
Individual strategies for each disease

Operational procedures manuals
Decontamination
Destruction of animals
Disposal procedures
Public relations
Valuation and compensation

Management manuals
Control centres management (Volumes 1 and 2)
Animal Health Emergency Information System
Laboratory preparedness

Enterprise manuals
Animal quarantine stations
Artificial breeding centres
Aviaries and pet shops
Feedlots
Meat processing
Poultry industry
Saleyards and transport
Veterinary practices
Zoos

Wild animal manual
Wild animal response strategy

Summary document

Earlier versions of this manual were prepared by a writing group with representatives from the Australian national, state and territory governments and industry. For Version 3.2, the document has been reviewed and updated by Glen Saunders of NSW Agriculture. Scientific editing was by Dr Janet Salisbury of Biotext, Canberra.

The revised manual has been reviewed and approved by the AUSVETPLAN Technical Review Group (TRG)

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The complete series of AUSVETPLAN documents is available on the internet at: http://www.aahc.com.au/ausvetplan/index.htm

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PART 1 STRATEGIC GUIDELINES

Part 1 of this manual provides the information needed for strategic planning of wild animal management programs, including:

- an introduction to wild animals in Australia, legislation and codes of practice (Section 1)
- emergency animal diseases of concern (Section 2)
- wild animal species, ecology and biology (Section 3)
- principles of disease control (Section 4)
- a key for decision making (Section 5)

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 animals include:

- *feral* animals (domestic animals that are free ranging or have 'gone wild');
- *exotic fauna* (eg foxes); and
- *native wildlife* (animals that are indigenous to Australia).

Feral animals and some introduced wild animals are often collectively referred to as *vertebrate pests*. These animals may be important in maintaining and/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 native wildlife do not appear to be at risk from many of the EADs of concern (see the **Summary Document** and the **Zoos Enterprise Manual, Section 1.2**). However, there are significant populations of feral animals 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 urban/stray dogs, and native dingoes.

Other species include wild birds and bats. Rodents are not included in this manual because, with the exception of Aujeszky's disease, their likely association with EADs is commensal. In an outbreak, commercial operators under direction from government agencies would probably handle control measures. While it is unlikely that any major control activities would be undertaken with these species, managers may well want to collect samples from them for disease surveillance.

Local knowledge is essential in assessing the status of wildlife populations. Similarly, wildlife/vertebrate pest officers or species experts/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 of things that may carry disease. Statutory provisions exist in all states/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.

The following state/territory legislation may impinge on the activities that may be undertaken in controlling wild animals during an EAD outbreak:

- 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 and/or destroy 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.

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 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 Geering et al (1995). Table 1 summarises the disease susceptibility of wild animal species.

2.1.1 African horse sickness

African horse sickness (AHS) is an infectious, insect-borne, viral disease of horses and mules. Horses are more susceptible than mules. In general, 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 virus-contaminated horsemeat. They usually contract a fatal form of the disease, and it is doubtful whether dogs play any role in the spread or maintenance of the disease virus.

Susceptible wild animals: horses, donkeys and dogs (but dogs do not transmit the disease)

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 only thought to be excreted for 5–6 weeks. In Europe, wild pigs can become infected and may be a reservoir of infection for domestic pigs.

Susceptible wild animals: pigs

Table 1 Emergency disease susceptibility of wild animal species

DISEASE[a]	Horse	Pig	Goat	Deer	Cattle	Buffalo	Camel	Donkey	Fox	Dog	Cat	Bird	Bat	Rodent
AHS[b]	■							■		■				
ASF		■												
Anthrax	■	■	■	■	■	■	■	■	■	■	■		▒	▒
Aujeszky's		■	■	■	■	■	■		■	■	■			■
Bluetongue			■	■	■	■								
Brucellosis				■	■	■								
CSF		■												
CEM	■							■						
EI	■							■						
FMD		■	■	■	■	■	■							
HPAI												■		
JE	■	■										■		
LSD					■	■								
ND												■		
PPR			■											
PRRS		■										▒		
Rabies	■	■	■	■	■	■	■	■	■	■	■		■	■
RVF	■		■		■	■	■	■	▒	■	■			■
Rinderpest		▒	■		■	■	■							
SGP			■											
SWF	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Surra	■	■	■	■	■	■	■	■	■	■	■			■
SVD		■												
TGE		■							■	■	■			
TSE			■	■	■	■					■			
VE		■												
VS	■	■			■	■		■						

a See Sections 2.1.1 to 2.1.27 below for definitions of diseases.
b See the abbreviations list for full disease names.

Key: ■ = susceptible ▒ = unknown □ = not susceptible

2.1.3 Anthrax

Anthrax is an acute infectious bacterial disease that can affect humans and a wide range of domestic and wild animals. 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, the disease is usually peracute; in horses it is acute and in pigs it is localised.

Anthrax in Australia is confined to certain regions and occurs only exceptionally. The disease has been reported in captive macropods overseas (Sen Gupta 1974), but no available literature describes it occurring in free-ranging animals.

Susceptible wild animals: most warm-blooded animals (including pigs, cattle, sheep, goats, horses, deer, camels, dogs, cats etc)

2.1.4 Aujeszky's disease (pseudorabies)

Aujeszky's disease is caused by a herpes virus 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 in 48 hours in dogs and often more rapidly in cats. Pigs may remain latently infected following clinical recovery.

Susceptible wild animals: pigs, cattle, buffalo, sheep, goats, deer, dogs, cats, foxes and rats

2.1.5 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: cattle, goats, buffalo and deer

2.1.6 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 and marine mammals; cross-infection of cattle by these species is usually limited to a single animal, but the pig parasite *B. suis* has become established in cattle in South America. Humans are susceptible.

Susceptible wild animals: cattle, buffalo and deer

2.1.7 Classical swine fever (hog cholera)

Classical swine fever (CSF) is a highly contagious and usually fatal viral disease 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, infection of wild pigs is important in the maintenance of the disease.

Susceptible wild animals: pigs

2.1.8 Contagious equine metritis

Contagious equine metritis (CEM) is a sexually transmitted disease of horses that causes endometritis, cervicitis and vaginitis in mares, resulting in temporary infertility 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: horses and donkeys

2.1.9 Equine influenza

Equine influenza (EI) 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. 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 only retains infectivity in the environment for a couple of days.

Susceptible wild animals: horses and donkeys

2.1.10 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 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.

Susceptible wild animals: cattle, buffalo, deer, pigs, goats and camels

2.1.11 Highly pathogenic avian influenza

Highly pathogenic avian influenza (HPAI) 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. 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.

Susceptible wild animals: many species of wild birds, especially waterbirds

2.1.12 Japanese encephalitis

Japanese encephalitis (JE) is a mosquito-borne viral disease of humans and animals that occurs throughout much of Asia. In pigs, it is mainly associated with abortion, and in humans and horses with encephalitis, which is often severe and fatal. 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. The susceptibility of other native fauna is not known, but they may prove to be significant hosts.

Susceptible wild animals: pigs and horses; inapparent infections in waterbirds, cattle, sheep, goats, dogs, cats, rodents, snakes and frogs

2.1.13 Lumpy skin disease

Lumpy skin disease (LSD) is an acute, highly infectious, generalised viral skin disease of cattle. It is caused by a member of the *Capripoxvirus* genus, similar to that which causes sheep 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: cattle and buffalo

2.1.14 Newcastle disease

Newcastle disease is a highly contagious and lethal viral disease of chickens, turkeys and other birds. Many species of wild birds are susceptible. Parrots and pigeons have been implicated in outbreaks overseas. Viral strains vary widely in their virulence. Severe strains cause rapid death. 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: many species of wild birds

2.1.15 Peste des petits ruminants

Peste des petits ruminants (PPR) in sheep and goats resembles rinderpest of cattle (see below) 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.

Susceptible wild animals: goats

2.1.16 Porcine reproductive and respiratory syndrome

Porcine reproductive and respiratory syndrome (PRRS) is caused by an RNA virus of the genus *Arterivirus*, which infects macrophages and thus compromises the immune response. 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: pigs

2.1.17 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. While 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. In different parts of the world, different species can be maintenance hosts. There are both urban and sylvatic (wildlife) rabies cycles. In urban cycles, dogs are the species responsible for maintaining and spreading rabies. With sylvatic rabies, the main maintenance hosts include members of the family Canidae (wild dogs, foxes, jackals, wolves), and other species including the raccoon, skunk, mongoose, meerkat and bats. If rabies is controlled in the maintenance species, the disease tends to die out. It is extremely important to determine the strain involved, as this will establish the key animals that need to be targeted in control programs. Depending on the strain of rabies introduced, sylvatic cycles could become established in Australia, involving wild dogs, foxes, bats or cats[1] as maintenance hosts. Recently, a lyssavirus closely related to rabies has been found in bats in Australia.

Susceptible wild animals: mammals; dogs, cats, foxes and bats are potential hosts

2.1.18 Rift Valley fever

Rift Valley fever (RVF) is a mosquito-borne 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.

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

2.1.19 Rinderpest

Rinderpest is an acute, highly contagious disease, for which cattle and buffalo are the major hosts. As well as cattle and buffalo, which are highly susceptible, rinderpest also affects giraffe, eland and kudu. Infection in wild artiodactyls with strains largely maintained 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.

The virus is related to the viruses that cause measles, canine distemper and PPR and is not stable in the environment. When the disease occurred in Southeast Asia, native breeds of pigs were quite susceptible, but European breeds were resistant. Many cloven-hoofed wild animal species in Africa are susceptible, including African buffalo and species of wild pig. There is no chronic carrier state. Because of their isolated populations, feral cattle and buffalo are unlikely to play a major

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[1] On their own, cats are unlikely to be a maintenance host. In the WHO World Survey of Rabies (WHO 1998) only 16 cats, compared with 884 dogs, were considered to be the source for cases of human rabies (www.who.int/emc-documents/rabies/whocdscraph996c.html).

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: cattle, pigs, goats, buffalo and camels

2.1.20 Screw-worm fly

Screw-worm fly (SWF) larvae can feed on living tissues in open wounds of any warm-blooded animal host, 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; however, screw-worm myiasis is rarely seen in birds.

Susceptible wild animals: potentially all wildlife species

2.1.21 Sheep pox and goat pox

Sheep pox and goat pox (SGP) are closely related diseases, often with a high mortality rate. 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: goats

2.1.22 Surra

Surra is a haemoparasitic disease caused by the trypanosome *Trypanosoma evansi* and 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 naive animals. The disease is most severe in horses, donkeys, mules, deer, camels, 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: horses, donkeys, deer, camels, dogs, cats, cattle, buffalo, goats, pigs, foxes and rodents

2.1.23 Swine vesicular disease

Swine vesicular disease (SVD) is caused by an enterovirus closely related to the human Coxsackievirus B5. It is characterised by fever and lameness due to vesicles and erosions on the feet. It is clinically indistinguishable from FMD. The virus is resistant to inactivation. Feral pigs could become infected through eating contaminated garbage.

Susceptible wild animals: pigs

2.1.24 Transmissible gastroenteritis

Transmissible gastroenteritis (TGE) is an enteric viral disease of pigs, caused by a coronavirus, which results in rapid death of piglets less than three weeks of age. Disease only occurs in pigs, although dogs, cats and foxes are susceptible to infection. The virus is spread by the faecal–oral route. Recovered pigs occasionally become carriers. Dogs, cats and foxes may be a source of infection for pigs.

Susceptible wild animals: pigs, dogs, cats and foxes

2.1.25 Transmissible spongiform encephalopathies

The transmissible spongiform encephalopathies (TSEs) 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: cattle, buffalo, goats, 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, related to the BSE epidemic, 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 the United States. Most cases have been in captive deer, but some 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.

2.1.26 Vesicular exanthema

Clinically, vesicular exanthema (VE) is indistinguishable from FMD. The VE virus is very closely related to viruses 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: pigs

2.1.27 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 involved, including New World species of wildlife (deer, antelope, bighorn sheep, monkeys, rodents and bats).

Susceptible wild animals: horses, donkeys, cattle, buffalo and pigs

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* and/or *spread* disease.

A number of ecological factors affect disease transmission, maintenance, dispersal and rate of spread.

- *Population distribution and density* — affect contact rates between susceptible and infective animals. Disease maintenance and transmission are enhanced at higher densities, while the distribution of wildlife can determine the area over which a disease is likely to occur (eg isolated versus continuous).

- *Habitat requirements* (including food requirements, refuges and denning sites) — directly linked to the likely density and distribution of wildlife hosts and the limitations of control operations.

- *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* – normal breeding and seasonal behaviours will lead to variability of contact rates, range size and population density.

- *Age structure of population* — disease dynamics differ between populations with a uniform age distribution and those with a high turnover (eg diseases with a long latent period might be detected only in older animals).

- *Home range* — directly determines the area over which the disease can be spread and the likely requirements of population control. As a general rule, the larger the animal the larger the home range.

- *Movements and distances travelled* — there may be sex and seasonal as well as 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 variation 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. These can also be used as boundaries to 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* — for example, at water points.

Local wildlife/vertebrate pest officers or species experts/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 emergency animal disease (EAD) outbreak is unclear. There is enormous variation in their distribution, density and habits 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 all year round where water, food and other necessary resources are abundant. As a guide, the key factors likely to influence the maintenance and/or transmission of an EAD and its control in each wild animal species are presented in the boxed summaries below. Some of the main ecological and biological attributes are shown in Tables 2, 3 and 4 in Section 3.3.

3.2 Summaries of important ecological factors for wild animal species

3.2.1 Bats (Chiroptera)

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

The Megachiroptera include not only the larger bats, such as flying foxes or fruit bats, but also several small blossom bats. All megachiropterans are fruit-, blossom- or nectar-feeders. They have large eyes and simple oval ears, and their facial features resemble those of small foxes or dogs. They use their excellent night vision and sense of smell to find food.

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 over 100 000 individuals, a factor that would readily facilitate the transmission of disease agents.

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 thousands of kilometres. Bats are responsible for the majority of rabies infections occurring 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. They include Hendra virus (formerly known as equine morbillivirus), which has been the 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, a rabies-related virus that has caused two human deaths. Australian bats are considered to be natural hosts for all three viruses.

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.
- Fruit bats are largely restricted to tropical forests where succulent fruits can be found throughout the year. However, those living in temperate regions may engage in considerable seasonal migration in search of food.

Other factors

- Most of the 22 genera of Australian bats also occur in New Guinea and Asia.
- Bats play a very important role in controlling insect populations, in plant pollination and in spreading seeds.
- Eradication of bats, except through habitat destruction in a confined location, is not feasible.

3.2.2 Buffalo (*Bubalis bubalis)*

Feral buffalo, once widely distributed near permanent water in the Northern Territory, have had their distribution and density drastically reduced by the Brucellosis and Tuberculosis Eradication Campaign. By 1990, buffalo only existed in large numbers in Arnhem Land and as tuberculosis-free domestic stock. Their numbers are expected to increase when the campaign ends in the near future (Henzell et al 1999).

KEY FACTORS — BUFFALO

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

- The distribution of feral buffalo overlaps those 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 all 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.
- In the wet season, bulls and cows congregate (up to 500 animals) 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 buffalo is limited, being confined to the 'Top End' of the Northern Territory.
- They 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 has been highly successful in locating residual buffalo.

3.2.3 Camels (*Camelus dromedarius*)

Feral camels are irregularly distributed throughout the arid zone of central Australia. They tend to live in the most remote areas, away from habitation (Siebert and Newman 1989), in sand dune and spinifex (*Triodia* spp) country (Short et al 1988).

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.
- They can travel great distances (50–70 km per day and up to 5500 km per year).
- They compromise the security of other animals by damaging cattle fences.

Factors that reduce the risk

- Feral camel populations have low densities.
- They inhabit very remote areas, away from habitation.

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; and
- *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 (Wilson et al 1992). Cats are very susceptible to rabies and are becoming the principal source of infection for humans in some countries (Bunn 1991).

KEY FACTORS — CATS

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

- Feral cats are widely distributed across Australia.
- They are highly adaptable and can survive and reproduce in almost all habitats.
- The density of wild cats is often highest where they are associated with humans (stray cats).
- They 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.
- While 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; and
  - movement away from the natal home range (settling some 4–8 km away) by young males before breeding (other immature animals 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 occur in many rugged and remote areas where it is difficult to muster. Their numbers in northern Australia have been greatly reduced during the Brucellosis and Tuberculosis Eradication Campaign (Wilson et al 1992). Feral cattle often occur 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 and/or disease control purposes. They are neither widespread nor abundant.

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

Six species of feral deer occur in Australia: chital (*Axis axis),* sambar *(Cervus unicolor)*, rusa *(Cervus timorensis)*, hog *(Axis porcinus)*, red *(Cervus elaphus)* and fallow *(Dama dama)*. These species occur over much of Australia, except in semiarid and arid areas and Western Australia, but are usually found only 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. Deer are generally found in vegetated hilly areas interspersed with agricultural land, although they have little contact with domestic animals (Henzell et al 1999). However, in Tasmania, deer may graze close to domestic stock.

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); they form large groups (up to 100 animals), which increases the probability of disease spread.
- They 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.

Factors that reduce the risk

- The distribution of feral deer is limited to small, localised populations, so deer are unlikely to play an important role in an EAD outbreak.
- Sambar and hog deer, in particular, are solitary or live in small groups.
- Their dispersal is limited by hunting pressure and lack of suitable habitat.

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

Wild dogs in Australia can be separated into three groups: the dingo (*Canis familiaris dingo*); the wild domestic dog (*Canis familiaris familiaris*); and the hybrid of these two.

There are also stray urban dogs, which may also play a role in the spread of canine rabies.

The dingo was originally distributed throughout mainland Australia. Today, pure dingoes are most commonly found in the northern part of Australia, hybrid dogs on the southeast coast and in the southwestern corner, and wild domestic dogs near towns and cities. There are no wild dogs in Tasmania (Wilson et al 1992).

KEY FACTORS — DOGS

Factors that increase the risk of maintaining, transmitting and dispersing 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 all year in cooler temperate climates (eastern highlands) and produce up to two litters of 4–5 pups per year.
- They form packs/groups, which increases the risk of disease transmission between the animals.
- Dingoes disperse when food availability is limited, potentially spreading disease over large areas.

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 (forays of dingoes out of their territory or range are rare).
- The presence of natural (escarpment) and constructed (dingo fencing) barriers limits their dispersal.

3.2.8 Donkeys *(Equus asinus)*

Feral donkeys occur predominantly in open country, in northern Western Australia, the Northern Territory and northern South Australia, and in isolated pockets of Queensland and New South Wales. Most of these areas are arid or semiarid. Donkeys are more sure-footed than horses and are often found among hills (Henzell et al 1999).

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 and have a habit of congregating in large groups (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.
- A successful removal method has been developed, involving continual ‘mustering up’ and killing of animals during control campaigns and not allowing surviving animals to disperse from the area during control (Wheeler 1987).
- Judas donkeys help to locate residual animals.

3.2.9 Foxes (*Vulpes vulpes*)

Foxes have become established throughout the southern half of Australia, with the exception of Tasmania and Kangaroo Island (Wilson et al 1992). 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 distribution also appears to be limited in the north by humid tropical conditions (Wilson et al 1992). In the north, their distribution is not continuous, and they occur in isolated pockets; for example in the Kimberley region of Western Australia and the Victoria River and Barkly Tableland of the Northern Territory (King and Smith 1985).

KEY FACTORS — FOXES

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

- Feral 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 persisting until new territories are established.
- Foxes disperse over long distances (up to 300 km for adult males).
- 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 many areas;
  - there is rapid reinvasion of an area following intensive control operations; and
  - bait shyness may occur in populations in areas regularly baited.

Factors that reduce the risk

- The risk of the fox 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.

3.2.10 Goats (*Capra hircus*)

Feral goats occur in all states, in the Australian Capital Territory and on several islands off the Northern Territory coast. They are most prevalent in hilly or scrubby parts of the sheep-grazed, dingo-free areas of Queensland, New South Wales, South Australia and Western Australia, and in isolated colonies in scrub patches in the agricultural areas of these states (Henzell et al 1999). Within these areas, their numbers are limited by food availability, water, predation and disease, either alone or in combination (Parkes et al 1996).

KEY FACTORS — GOATS

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

- Feral goats breed all 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 600 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 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 survey and control operation difficulties.

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 has been effective for locating and removing recalcitrant goats.

3.2.11 Horses *(Equus caballus)*

Feral horses are widely distributed in arid and semiarid northern and central Australia, predominantly in flat to rolling open country (Henzell et al 1999) and in cattle-raising areas. Smaller, isolated populations occur in wetter areas of southern Australia, especially the Australian Alps. There are no feral horses in Tasmania or the Australian Capital Territory (Dobbie et al 1993).

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 areas used for cattle raising.
- They live in overlapping home ranges, in harems or bachelor groups, and their congregation in large, cross-social groups (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, but missed, 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, mares generally having 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 widely distributed throughout a range of habitats in Queensland, the Northern Territory, New South Wales and the Australian Capital Territory. Isolated populations occur in Victoria, South Australia, Western Australia and on Flinders Island in Bass Strait. In mainland Tasmania, accidental releases led to small, temporary populations. In inland and seasonally dry areas of Australia, feral pigs are restricted to the vicinity of watercourses and associated floodplains. Populations are, however, still spreading in the more forest-covered parts of eastern and southwestern Australia where access to daily water and shelter are not limited (Choquenot et al 1996).

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 carcases.
- 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 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.
- 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.
- The Judas animal method may be successful with recalcitrant pigs.

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

Tables 2, 3 and 4 summarise relevant characteristics of the main feral animal species in Australia. Data are not available for some attributes of some species.

Table 2 Biological and ecological attributes of feral herbivores

Attribute	Goats	Camels	Buffalo	Donkeys	Horses	Cattle	Deer
Density							
– max (per km^2) over 100 km^2	40[a]	3[a]	15[a]	10[a]	10[a]	10[a1]	3 (fallow)[a]
– range (km^2)	0.6–26[b] 1–3[c] 9[d] 0.6–7.5[e]	0.12[h] 0.78[i]		0.13[o]			8.7 (males) 5.9 (females)[t]
Australian population (thousands)	2000–3000[a]	100[j]	10[a]	2000–5000[p]	350–600[a]		≤20 (fallow)[a] 5 (sambar)[a]
Home range (km^2)	100[f]; 2[g] ≤600 (♂)[a] ≤200 (♀)[a]	10 000 to 58 000[h]	200–1000 ha[n]	?	70 (52–88)[q] 100[r]		60 (fallow stags)[a], 13 (females)
Movement (km)	30 km/ 6 wks	5500/yr[h] 50–70/ day[k]	Small				
Social organisation							
– common group size	10–40[a]	1 to 5[l] 2 to 45[i]	30–50[a]	5–30[a]	5–7[q1]; 1–4[q2]; 1–3[q3]	10–30[m] 3–12[m]	1–20[a,t] 5–12 (chital)[s]
– max group size	1000[a]	500[j]	500[a]	500[a]	100[a]		400 (fallow)[a] 100 (chital)[a]

a Henzell et al (1999); a1 feral and domestic, in pastoral areas
b Lord Howe Island
c Arid/semiarid rangelands Western Australia (Southwell and Pickles 1993)
d Western/rangelands NSW (Maas and Choquenot 1995)
e NSW (Mahood 1985)
f Arid areas
g High-rainfall areas
h Wurst (1996)
i Short et al 1988
j Dorges and Heucke (1995)
k Siebert and Newman (1989)
l Wilson et al (1992)
m McKnight (1976)
n Corbett (1995b)
o Bayliss and Yeomans (1989) — northern limit of their range
p Choquenot (1995)
q Harems (Dobbie et al 1993), q1 central Australia, q2 eastern Australia; q3 bachelor groups
r Mitchell et al (1982)
s Bentley (1995)
t Statham and Statham (1996)

Table 3 Biological and ecological attributes of feral pigs

Density (pigs per km^2)	
– highest (wetlands, swamps and floodplains)	1 to >20
– lowest (forests and semiarid regions)	0.1–4
Australian population	13.5 million[a]
Home range (km^2) (where food supply is poor, home ranges are larger)	
– male	1.4–43
– female	1.5–19.4
Social organisation	
– common group size	1–10
– maximum group size	>100[b]

a Hone (1990) recommended that current estimates should be treated with caution
b In severe drought in tropical northern Australia
Note: See Choquenot et al (1996) for detailed information and references for research across Australia.

Table 4 Biological and ecological attributes of feral cats, wild dogs and foxes

Attribute	Feral cats	Wild dogs	Foxes
Density (per km^2)[a]			
– highest	In association with rabbits and humans; insular populations; open habitats	Density increases in areas with more watering points, better food supplies and human settlement causing accidental release	4.6–7.2[g] 0–12[h]
– lowest	Mainland populations; closed forest or wet heath		0.2[i] 0.6–0.9[j]
Australian population			
Home range (km^2)			
– male	6.2[bc], 4.1[bd]	Males larger than females	
– female	1.7[c]	10[e]–77[f]	
– range			340[k]–610[l]
Social organisation		Highly flexible:	
– common group size	1	– solitary when small prey dominant	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

a There are few estimates of feral cat densities in Australia; comparison between studies is difficult due to differences in methodology and seasonal effects.
b Diurnal range
c Semiarid southeastern Australia (Jones and Coman 1982)
d Macquarie Island (Brothers et al 1985)
e Moist areas — Nadgee Nature Reserve (Corbett 1995a)
f Arid regions — Fortescue River, northwestern Australia (Corbett 1995a)
g Temperate grazing, NSW northern tablelands (Thompson and Fleming 1994)
h Urban Melbourne (Marks, quoted in Saunders et al 1995)
i Dry sclerophyll forest, NSW south coast (Newsome and Catling 1992)
j Semiarid grazing, southwest Western Australia (from Saunders et al 1995)
k Farmland/woodland, Western Australia (from Saunders et al 1995)
l Farmland, Victoria (Coman et al 1991)

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 The challenges wild animals present to disease controllers

Wild animals often live in areas where their control and containment are both difficult and expensive. Moreover, control and containment could take months to achieve, 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 and disperse a considerable distance away from attempts to contain and eliminate them. 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. Although this wild animal response strategy concentrates mainly on introduced species (feral animals), epidemiologists should be mindful of the possible involvement of native species in EAD epidemiology.

4.3 Principles of disease control in wild animals

The first requirement is to ascertain what 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, 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 population immunity by the use of vaccine 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 their respective individual threshold densities.

In the case of rabies, the time taken for detection of development of sylvatic disease 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 crossover.

In any particular outbreak, the following sequence describes 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 2 (Operational guidelines) of this manual.

4.3.1 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.

4.3.2 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 give an indication of the extent of its spread.

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

4.3.3 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.

Containment of the disease will usually involve defining a wild animal control area by surrounding the known extent of disease, based on the estimated rate of lateral spread and allowing for the incubation period of the disease. Techniques are defined in Section 9 of this manual.

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. Alternatively, containment may involve rapidly destroying all susceptible 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 area's outer margins. In some situations, disease eradication may involve doing nothing — that is, if the area is well contained, allowing the disease to run its course and die out naturally.

Containment may be impractical for diseases in which insect vectors are involved.

4.3.4 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.

4.3.5 Step 5 — Demonstrate freedom from disease

The state 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 of this manual. 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 officers to guide decision making on operations involving wild animal species.

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

- 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.

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

In making this decision, consider reliable knowledge of such factors as known relationships between the disease and wildlife (worldwide) and distribution of wildlife in the vicinity of the disease outbreak.

Yes. Go to.. 2

No. Go to 5

Do not know. Go to 3

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

Yes. Go to.. 8

No. Go to 5

PART B — SURVEILLANCE Steps 3 to 8 are short- to medium-term actions.

3 Determine the distribution and abundance of susceptible wild animal hosts

Determine the distribution and abundance of potential 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.. 4

No. Go to 5

4 Do we know if wild animals and/or domestic animals are infected?

Disease thought to be present only in domestic animals. Go to.................................. 5

Disease thought to be present in domestic animals, with the status of wild animals unclear. Go to 5

Disease thought to be present in both wild animals and domestic animals. Go to 5

Disease thought to be present in wild animals, with the status of domestic animals unclear. Go to 6

Disease thought to be present only in wild animals. Go to.. 6

5 Should we ignore wild animals?

Consult with a wildlife/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/real consequences of inaction are of little importance. Go to 13

Wildlife cannot be ignored. Go to 6

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 'getting it wrong'.

Consult experts[2] to consider/initiate the following:

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

See Part 2 (Operational guidelines) of this manual.

If disease is detected in wild animals, go to 8

If no disease is detected in wild animals, go to 7

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

7 Relevance of wild animals

Where there are inadequate data:

If disease control in domestic animals does not proceed as quickly as expected, and, where relevant, consider increasing the intensity and range of testing of wild animals. Go to 6

It may be necessary to wait for a period, taking into account the decision factors (Section 5.3). Go to 6

Consider whether to control and contain wild animals as a precautionary measure, taking into account the decision factors (Section 5.3). Go to......................... 9

Where there are reliable data and:

no disease is detected in wild animals during sampling, go to.................................. 13

disease is detected in wild animals during sampling, go to 8

---

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

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.

8 Select appropriate control and/or containment strategies

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

No targeted action against wild animals. Go to.. 9

Nonlethal disease control measures (including vaccination). Go to.......................... 10

Lethal disease control measures for wild animals, and containment. Go to 11

Modify control and containment methods depending on outcomes/assessment.

Disease is no longer detected in susceptible hosts. Go to... 12

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

9 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 2 (Operational guidelines) of this manual and the relevant **Disease Strategy**.

If there is continuing or increasing concern over disease in wild animals, go to.. 8

If there is insignificant or no concern about disease in wild animals. Go to 12

10 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 2 (Operational guidelines) of this manual and the relevant **Disease Strategy**.

Disease is still detected in susceptible hosts. Go to 9

Disease is no longer detected in susceptible hosts. Go to... 12

11 Lethal disease control measures for wild animals, and containment

Implement appropriate methods to control and contain wild animals, taking into account the decision factors (Section 5.3). Refer also to Part 2 (Operational guidelines) of this manual and the relevant **Disease Strategy**.

Modify control and containment methods depending on outcomes assessment.

Disease is no longer detected in susceptible hosts. Go to 12

Susceptible hosts eradicated. It may be necessary to exclude wild animals from the wild animal control area until any remaining disease agent is inactivated. Go to 12

Wild animals reduced below disease threshold level and disease no longer detected. Go to 12

Wild animal disease control operations fail to prevent expansion of outbreak and disease is declared endemic. Go to 14

<u>12 Monitor for residual disease</u>

Disease detected. Go to 5

Disease not detected. Go to 14

<u>13 No action to be taken against wild animals</u>

Periodically review the situation.

Developing concern. Go to 5

No concern. Go to 14

Factors to consider in making this decision:

- no wild animal species present is important in the maintenance and transmission of the disease;
- wild animals, even if infected, are unlikely to be a source of infection for domestic animals and/or people;
- any disease in wild animals will not persist after infection has been eliminated from domestic animals;
- disease control in domestic animals (if commenced) is proceeding as expected;
- action to test for the presence of disease in wild animals or to control wild animals is likely to have adverse consequences, for example:
  - spread of disease by dispersing wild animals
  - reinfection of domestic animals by wild animals
  - undue slowdown in disease control or other operations.

<u>14 Cease operations — no further action</u>

The disease has been declared:

- endemic; or
- eradicated; or
- unresolved.

5.3 Decision factors

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

- epidemiology
- ecology
- resources
- sociopolitical factors.

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

5.3.1 Epidemiological factors

Disease control can be achieved by drastic population reduction or by mass immunisation of the host species. In both cases, the aim is to reduce the number of susceptible animals to below the threshold density (K_t) of animals that is necessary to maintain the disease in the wild. The main epidemiological factors that need to be taken into consideration are shown below.

Characteristics of the disease

The main relevant characteristics are:

- mode of spread
- infectivity
- incubation period
- mortality and morbidity
- rate of spread
- carrier status.

These characteristics will all have an effect on the type of operation (eg with rabies, vaccination of susceptible wild animals may be a more viable 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 is due 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 elimination from domestic animals.

Density sought after control

The population reduction required will depend on:

- the disease
- the susceptible species present
- the epidemiological situation.

Need for carcase disposal (see the **Disposal Manual**)

This could influence:

- the choice of control method, as well as
- the decision as to whether or not to control wild animals.

Control of the disease by vaccination or other nonfatal methods

This could depend on:

- the effectiveness of conventional control techniques; and
- the availability of, and authority to use, vaccines.

5.3.2 Ecological factors

Location

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

Season

The season will affect wild animal movement patterns, social behaviour, contact rates and drinking behaviour, and 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 might be employed in sequence as the density falls.

Desired density sought after control

See Section 5.3.1.

Attainability of desired density

Whether 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 sympatric species are susceptible, try to use the same technique against all species, so that techniques used against one do not prejudice the elimination of disease from others.

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

Are sufficient human and material resources available to mount the operation? There may have to be a compromise between the intensity of control and the area covered.

Attainability of target density

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

Need for carcase disposal (see the **Disposal Manual**)

The ability to locate and dispose of carcases will be resource dependent. This could influence the choice of control method, as well as the decision on whether to control wild animals.

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 (wildlife and 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.

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. There will be considerable experience in the delivery of toxic baits, the technology for which is transferable. 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

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

Economy

What will be the likely effect on the local, regional and national economies?

Attainability of desired density

See Section 5.3.2.

Legal ramifications

The relevant state and national legislation, likelihood of litigation, and the legal powers/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 carcase 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 and/or national policies on EADs, wild and/or feral animals, rural assistance etc, together with related policies, will influence the scale and type of operation.

PART 2 OPERATIONAL GUIDELINES

Part 2 of this manual provides operational guidelines that briefly describe procedures and techniques for:

- population surveys (Section 6)
- disease sampling (Section 7)
- population reduction (Section 8)
- population containment (Section 9)
- sympatric species operations (Section 10)
- management (role descriptions) (Section 11)

These are only guidelines. 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. These can include animal welfare, occupational health and safety practices, the safe use of chemicals, environmental contamination, nontarget effects, the presence of threatened communities and the views of Indigenous owners. Also, consider in the planning stage how information collected within each of these sections is to be managed, stored, interpreted and relayed to local disease control centre (LDCC) personnel. The preparation of regular formal situation reports is integral to this process.

6 Population surveys

6.1 General information

Some states have geographic information systems (GIS) of wildlife distribution and density estimates. All surveys should be undertaken in a manner compatible with the instructions contained with the **Mapping Manual.**

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 indicate 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 and/or containment achieved); 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.

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. The area may be too large in the first instance, increasing the time required for the survey and placing excessive demands on available resources. Refer to Section 3 for notes on species ecology.

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 a circle of radius at least equal to the maximum likely length of the largest home range of any susceptible species present (allow for the marked asymmetry of some home ranges). For information on species home range, 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.

Large outbreak in domestic animals, with wild animals uninfected

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

Large outbreak in domestic animals, with wild animals possibly infected

If the disease might have entered 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, and survey an area including this area and a buffer area of a width similar to that given above.

Wild animals infected

Where disease is present in wild animals, survey an area that includes the likely limits of spread. It will probably not be known how long the disease has been in Australia or even if the cases detected are the index cases. 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 (the zone might need to be made wider to allow for animal movement). The likely rate of spread should be estimated by the epidemiologist and a wildlife biologist (if possible, they should both be familiar with the relevant species). Surveying may be simplified, and followed by a later, more detailed survey.

6.2.2 Population assessment teams

Population assessment teams should generally consist of:

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

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

Population assessment teams will be briefed at the LDCC on where they are to operate, what to look for, what techniques to use, reporting, data recording and decontamination procedures. 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 from which all new information is entered to a centralised database each day);
- use 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 (see the **Mapping Manual**).

6.3 Techniques and species-specific information

The choice of technique will influence the accuracy of survey data (see Table 5). 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 and/or where the terrain is inaccessible or rough. Ground survey techniques, such as track and dung counts, are more appropriate for such species 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/wildlife biologists.

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.

Table 5 Survey techniques for distribution and abundance, and considerations for wild animals

Technique	Species	Comments
Aerial survey – helicopter and fixed wing	Buffalo, camel, cattle, deer, donkey, goat, horse, pig	Various methods (strip transect, double count, total count). Needs experienced personnel. Sightability affected by habitat, group size, weather and time of day.
Ground survey	All species (variable).	Highly variable outcomes and accuracy.
– spotlight and day counts	Depends on nocturnal/diurnal behaviour	Dependent on habitat, vehicle access, species, previous control history (eg shooting makes animals wary of spotlights). Sample all habitats in area. Use line transect methodology wherever possible.
– trapping	All species (including rodents, wild birds, bats)	Requires time (varies by species). Only to be used together with population reduction and/or disease sampling, or where other methods cannot be used.
– sign	All species	Various methodologies, including dung count, track counts, den count, surveys of rooting, wallows, rub marks. Use initially only as crude index and follow up with other methods.
– free feeding	Most species (not well tested)	Select bait according to likely species; beware of nontarget take. Requires time; sample all habitats. Use initially only as 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 etc.

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 getting access to animals or faeces and the use of a test to diagnose the disease. Obtaining animals 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
- carcase collection.

The test procedure may involve a simple inspection of animals for the presence of characteristic disease lesions, or it may involve the collection of blood or other tissue samples, from which isolation of the disease agent may be attempted or the presence of antibodies demonstrated. Blood is one of the most common samples collected for diagnosing disease, because serological testing (the 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 used for determining the sample size required 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 transposed from domestic species and may not perform identically in wild animals. There may be differences in host responses, and wild species may be exposed environmentally 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;
- what areas to sample;
- how to obtain animals for sampling;
- what samples are required; and
- how to interpret the findings.

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

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

See Section 5 of this manual 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 wildlife and/or vertebrate pest control experts, the likely distribution of the wild animal species in the area should be determined (see

Section 6). First, whether the disease is present should be determined. Sampling should be concentrated on areas where animals are considered most likely to have come into contact with the disease (eg through likely contact with infected livestock or because of the likely presence of 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 EpiInfo, Win Episcope, FreeCalc) 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, as many animals as physically possible should be captured and sampled, particularly in the vicinity of an infected premise (IP) and within and surrounding the restricted area (RA).

7.3.1 Is the disease present?

From the emergency animal disease management point of view, the key question is whether the disease is present in wild animals (see the decision-making key in Section 5). To answer this question, random sampling is less important than it is 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, recognising that it may only be necessary to test a few of these to be confident of finding disease.

7.3.2 Determining the extent of spread

Once the disease is found in the 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 (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 disease has been present and for estimating how quickly it is spreading, and can 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 are 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

While 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, according to the relevant OIE (World Organisation for Animal Health, formerly Office International des Epizooties) Terrestrial Code chapter(s). For proving freedom from the disease, a wide-area survey (that could involve domestic animals) is required rather than a focus on high-risk areas. While a true random sample may be impossible, it is important to use as random a process 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 that can be placed in the results. Provided the above variables are known or can be estimated, tables (eg Cannon and Roe 1982) and various computer software packages (eg EpiInfo, Win Episcope, FreeCalc) are available for determining sample size. Alternatively, having tested a random proportion of animals in a population and found no positives, the confidence level can be determined. For proving freedom from a disease, 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 to 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 reduction of the population of wild animals in the vicinity of an outbreak, in which case 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.

Surveillance teams will be briefed at the LDCC on where they are to operate, what to look for, what samples are required, decontamination procedures and how to deal with carcases.

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/control procedures.

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

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 carcases;
- use GPS to more accurately record sampling sites;
- identify specimens individually and 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 (see the **Mapping Manual**).

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). See also the **Laboratory Preparedness Manual** and the relevant **Disease Strategy**).

Once samples are taken, carcases 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 6) 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. Alternatives that could be considered include:

- free feeding to facilitate good observations of animals for clinical signs;
- food trapping, using food as an attractant;
- collection of fresh road kills;
- collection of carcases 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 wildlife and 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 using faeces 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 6 Disease sampling techniques and considerations 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[b]	At permanent water, and for animals 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.[c] For birds, consider shooting at night with silenced rifles, using red light for illumination.
Trapping or netting[a] (mist and hand nets are also used for wild birds and bats)	All species[b] (including rodents) Wild birds	For long-term disease monitoring and sentinels. Only to be used together with population reduction; or where other methods cannot be used, when there are small numbers or in hot weather when birds are near water.
Mustering	Buffalo, camels, cattle, deer, donkeys, goats, horses	Consider using dogs
Judas animals	Buffalo, cattle, goats, pigs	For long-term disease monitoring and observations
Helicopter net guns	Deer, goats	Where live animals are required
Free feeding, food trapping	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 (by hunters, bushwalkers etc)	All species[b]	Has been used overseas to facilitate the detection of rabies. An inducement and/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.
b Including birds and bats
c Wilson and Choquenot (1997)
Note: Refer to Section 8 (Population reduction) for details of techniques and advantages and disadvantages; 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, Disease sampling). If wild animals are considered to be a risk factor in the dissemination or persistence of infection, then 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 of this manual.

In all disease situations, unrealistic expectations of wild animal control or depopulation operations must be avoided. Consider also that the removal of wild animals from an area may create a 'sink' into which healthy and infected animals might 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 might die out naturally in low-density wild animal populations. Another option is the use of vaccine, for example in the case of rabies, with a trap–vaccinate–release program as applied in 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 and/or vertebrate pest control officers, 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.

Consider that most techniques (eg poisoning and trapping) will take weeks to achieve the target density.

Consider the potential knock-on effects of control operations, such as nontarget risk, the welfare of target and nontarget animals, and environmental contamination. Consider the sequential use of different techniques. Vary the technique 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 (or are suspected to be 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*.

Determination of the population reduction 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 and/or wildlife officers, where possible; and
- at least one officer (two is desirable) experienced in wild animal capture/control procedures.

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

Briefing

Control teams will be briefed at the LDCC on where they are to operate, what to look for, what techniques are to be used, reporting and data recording procedures, decontamination procedures and how to deal with carcases. Teams will report to the wild animal control team leader and/or wild animal control and surveillance coordinator (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 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 (see the **Mapping Manual**).

Note: Carcases 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 section of the **Disease Strategy** (references to wild animals are usually found in Sections 2.2.10 and 3.2.8 of the strategies).

Selection of technique will depend on:

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

The techniques specific to each species are presented in Table 7. It will be necessary to tabulate the performance targets achievable with each technique for each species, taking into account density, dispersal, ease of carcase disposal, use of resources available 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 (highest to lowest): helicopter shooting, dogging, ground shooting, spotlight shooting, mustering, trapping, fencing, ground poisoning, aerial poisoning. The potential risk dispersal may create for disease spread must be considered.

Table 7 Population reduction and disease control techniques, and considerations for wild animals

Technique	Species	Comments
Lethal control		
Helicopter shooting	Buffalo, camel, cattle, pig, donkey, goat, horse	Rapid control with concurrent control of sympatric species possible in open floodplain, grassland and swamp habitats; inaccessible/uneven terrain; not suitable in heavy cover May utilise Judas animals
Ground shooting	All species	Spotlight shooting for most species; from a hide for deer and birds May utilise Judas animals
Poisoning	All species	Achieved from ground and/or air, depending upon the habitat Poisoning — 1080 for all species;[a] warfarin for pigs;[a] strychnine for foxes and wild dogs;[b] cyanide for foxes;[b] — has been used with variable results in Australia. Check on current legal status and conditions of use before using these poisons. Licensed, experienced vertebrate pest control officers must be used to mix and distribute baits.
Gassing	Fox	Not labour-efficient; appropriate only during the denning season
Live capture		
Trapping[c]	All species	Use at water, with lures, food or baits
Judas animals[d]	Buffalo, cattle, goat, pig	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. Method has had limited success for pigs. For goats, use dogs to hold animals for capture or while they are shot (unproven for other species). 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 test them for disease regularly.
Mustering	Buffalo, camel, cattle, deer, donkey, goat, horse, pig	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	Fox	Oral vaccination is effective and more desirable than population reduction as it is less disruptive to species population dynamics, and because foxes are generally resilient to persecution.[b] Do not attempt population reduction while vaccinating.

contd…

Table 7 Population reduction and disease control techniques, and considerations for wild animals (continued)

Technique	Species	Comments
Urban control of rabies	Urban and stray dogs	'Managed population' and 'immunised population' approaches
Large-scale burning off	Buffalo, camel, cattle, deer, donkey, goat, horse, pig	Use only in exceptional circumstances
Small-scale burning off	Buffalo	To produce green pick during dry season
Human sweep line	Buffalo, camel, cattle, deer, donkey, goat, horse, fox	Use only under exceptional circumstances
Sedatives	Feral goats	Unproven for other species
	Birds	Alpha-chloralose has been used
	Fallow deer	Diazepam used successfully in Tasmania

1080 = sodium monofluoroacetate

a See Wilson and Choquenot (1997) for feral pig poisoning methods.

b See Saunders (1999) for information on methods and bait types.

c Trap design differs between species; nets will also be used for wild birds and bats; a wildlife biologist or wildlife/vertebrate pest control officer will design or advise on traps.

d 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.

Helicopter shooting

Advantages

- useful to obtain samples quickly;
- can cover large areas rapidly;
- rapid control of large number of animals with concurrent control of sympatric species possible;
- suitable for a wide range of larger species, such as horses, donkeys, cattle, buffalo, goats, camels, deer and pigs; and
- 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; and
- may cause dispersal (possibly mainly in high-density populations).

Samples will be required early in the outbreak, so generally the quickest retrieval method is recommended. This is most commonly helicopter shooting.

Ground shooting

Advantages

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

Disadvantages

- relatively slow and time-consuming compared with helicopter shooting; and
- will need many teams to cover large areas.

Poisoning

Routine poisoning of vertebrate pests (feral pigs, rabbits, wild dogs, 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 (pigs) and cyanide (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.

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/territory departmental chemicals coordinators *before* using them.

Advantages

- minimised disturbance; and
- reduced risk of dispersal.

Disadvantages

- need to allow for a period of free feeding if poison bait is used;
- nonspecific and may kill nontarget species;
- unless a quick-acting poison such as cyanide is used, it may be difficult to locate carcases;
- efficacy is variable, particularly with 1080; and
- it may be difficult to get 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 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.

Trapping

Advantages

- minimal disturbance;
- reduced risk of dispersal; and
- live animals are then available for use as sentinels or Judas animals.

Disadvantages

- may take a few weeks to achieve results; and
- need to allow a period for free feeding and/or familiarisation.

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

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.

Judas animals

In Australia, the Judas animal method has been successfully tested on feral goats (Henzell 1987) and has proved highly cost effective in Brucellosis and Tuberculosis Eradication Campaign control operations for cattle and buffalo in the Northern Territory (Carrick et al 1990; P Caple, Veterinary Officer, Northern Territory Department of Business, Industry and Resource Development, unpublished data, pers comm, 1997). It has had mixed results with feral pigs (Wilson and Choquenot 1997, McIlroy and Gifford 1997).

Judas animals obtained from among the population to be controlled are no more likely to disperse than any other members of the population. Judas animals obtained from elsewhere may be more likely to disperse, and 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.

- Because the animals are cheap, eradication is affordable in situations where it would not otherwise be contemplated.

- A population estimate can be calculated 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 reinvading 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 of this manual. Refer also 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;
- availability of existing natural or human-made barriers;
- timeframe, as it may take some time to fully implement a containment strategy; and
- availability of resources.

9.2.1 Containment teams

Membership

Containment teams should generally consist of:

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

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

Briefing

Containment teams will be briefed at the LDCC on where they are to operate, what to look for, what techniques are to be used, reporting and data recording procedures, decontamination procedures and how to deal with carcases. Teams will report to the wild animal control team leader and/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 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 (see the **Mapping Manual**).

Where feasible, carcases 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 carcases may compromise the speed of population containment, disposal may be necessary to ensure disease containment.

9.3 Techniques and species-specific information

Table 8 gives an outline of species-specific techniques.

Table 8 Containment techniques and considerations for wild animals

Technique	Species	Comments
Depopulation	All species	Use one or more of the techniques in Section 8 (Population reduction) to create a buffer area around the wild animal control area or the infected area
Helicopter patrol	Buffalo, camel, cattle, deer, donkey, goat, horse, pig	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 disturbance 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 to funnel buffalo to movement detectors).
Lure traps	Buffalo	Especially oestrous females 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 where 100% containment is vital; combine with illumination

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

10 Sympatric 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, be 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 5, 6 and 7).

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 better under 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 these 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 sympatric 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 carcases of other species (eg feral pigs, foxes, wild dogs/dingoes). Where the former are at risk of becoming infected or of spreading disease, control operations that leave contaminated carcases may be contraindicated. Alternatively, consideration may need to be given to disposing of or treating carcases.

11 Role descriptions

The number of managers/coordinators will depend on the scale of the outbreak and level of involvement of wild animals. Even if there is no person 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 have other responsibilities as well.

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

11.1 Extensive outbreak

In addition to the managers/coordinators listed below, 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 **Control Centres Management Manual**, Part 2, Role description LRD 400.

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 below), with broader responsibilities beyond the infected premises (IPs), including to:

- allocate/define operational areas; and
- coordinate and manage all wild animal control and surveillance activities within the restricted area and in IPs or dangerous contact premises (DCPs).

The main tasks are listed in the **Control Centres Management Manual**, Part 2, Role description LRD 401.

A *wild animal control coordinator* may also be appointed to the state disease control headquarters (see the **Control Centres Management Manual**, Part 2, Role description SRD 105).

11.3 Small-scale outbreak

A *wild animal control team leader* will be appointed to the 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/DCP and, where appropriate, in the RA; and

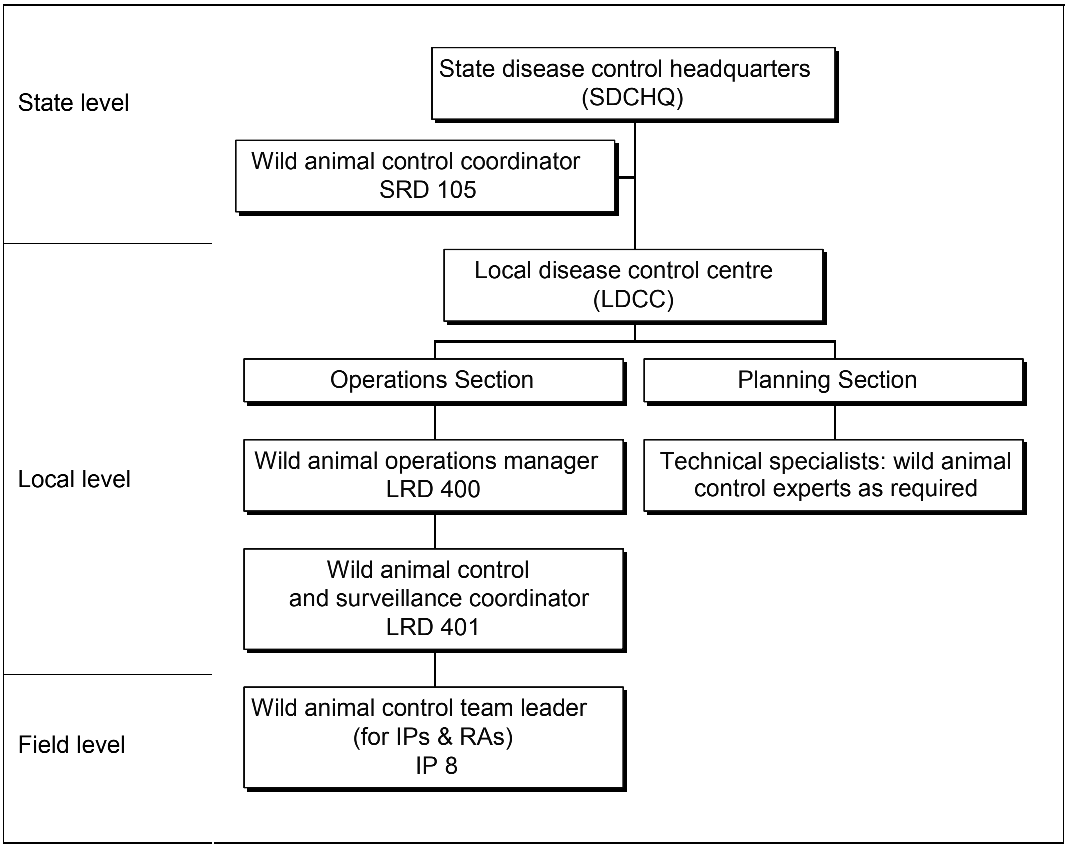
- plan and coordinate an effective population reduction/containment program, disease surveillance program and/or population survey program to minimise the risk of disease transmission, by coordinating activities of field staff.

The main tasks are in the **Control Centres Management Manual**, Part 2, Role description IP 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 (CA); and
- provide advice on the potential for wild animal disease spread, the effect on the size of the RA and the need for disease surveillance.

Figure 1 Structure of wildlife manager/coordinator roles



The actual structure will depend on the scale of the outbreak, as follows.

- A wild animal operations manager position (role description LRD 400) should be created only for extensive outbreaks.
- A wild animal control coordinator (SRD 105) attached to state disease control headquarters and the LDCC wild animal control coordinator (LRD 504) may be necessary for medium-scale and small-scale outbreaks.

- A wild animal control and surveillance coordinator (LRD 401) may be required for a small-scale outbreak.

Appendix 1 Sources of information

Species	Sources of information
All species	Consult local/state vertebrate pest control authorities[a] and control officers, national park rangers, landholders, local hunters and the wildlife biologist to determine the likely location and density of species. Also refer to the key documents listed below.[b]
Bats	Consult museums, universities, carer groups.
Buffalo	Consult the most recent aerial survey of the Northern Territory.
	Also consult Northern Australia Quarantine Strategy staff and buffalo catchers/harvesters.
Deer	The Australian Deer Association Inc 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.
Dogs/dingoes/feral cats	Consult local doggers and, where appropriate, the local/state authority responsible for wild dog destruction.
Feral goats	Consult commercial harvesters as to the location and number of goats shot and mustered in the area.
Feral horses/donkeys	As for all species (above)
Feral pigs	Also consult harvesters and chiller operators as to the location and number of pigs shot in the area.
Marsupials	In addition to national park rangers, consult local field naturalist and wildlife conservation organisations.
Wild birds	Consult local and state ornithologist groups, Birds Australia and domestic bird producers as to the location and species of wild birds in the area.

a Refer to the state or territory emergency disease management manual for contact details of organisations.

b Parkes et al (1996), Dobbie et al (1993), Choquenot et al (1996), Saunders et al (1995), Saunders (1999), Henzell et al (1999)

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

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
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 or territory) who has responsibility for animal disease control in that jurisdiction. *See also* Australian Chief Veterinary Officer
Compensation	The sum of money paid by government to an owner for stock that are destroyed and property that is compulsorily destroyed because of an emergency animal disease.
Consultative Committee on Emergency Animal Diseases (CCEAD)	A committee of state and 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 poison, shoot) and nonlethal (eg trap, vaccinate) methods.
Control area	A declared area in which the conditions applying are of lesser intensity than those in a restricted area (the limits of a control area and the conditions applying to it can be varied during an outbreak according to need).
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	Premises that contain dangerous contact animals or other serious contacts.
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.
Destroy (animals)	To slaughter animals humanely.
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 carcases, animal products, materials and wastes by burial, burning or some other process so as to prevent the spread of disease.

Emergency animal disease	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.
Endemic animal disease (EAD)	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	*See* Wild animals
Feral animals	*See* Wild animals
Feral herbivores	Buffalo, cattle, camels, deer, donkeys, feral goats and horses; that is, the large herbivores only.
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 non-infected 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.
Index property	The property on which the first or original case (index case) in a disease outbreak is identified to have occurred.

Infected premises (IP)	A defined area (which may be all or part of a property) in which an emergency disease exists, is believed to exist, or in which the infective agent of that emergency disease exists or is believed to exist. An infected premises is subject to quarantine served by notice and to eradication or control procedures.
Judas animals	Animals carrying radio transmitters that are released into an area and join up with local wild animals, allowing the entire group to be tracked.
Local disease control centre (LDCC)	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 meeting in May and published on the internet at: http://www.oie.int/eng/normes/mcode/a_summry.htm
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: http://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 point in time.

Primary Industries Ministerial Council (PIMC)	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 (RA)	A relatively small declared area (compared to a control area) around an infected premises that is subject to intense surveillance and movement controls.
Risk enterprise	A defined livestock or related enterprise that 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, avian influenza centres, veterinary laboratories and hospitals, road and rail freight depots, showgrounds, field days, weighbridges, garbage depots.
Sensitivity	The probability that a test will correctly identify animals that have been exposed to the disease (true positives). Exposed animals that do not give a positive test response are referred to as false negatives. *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 probability that a test will correctly identify animals not exposed to the disease (true negatives). Non-exposed animals that test positive are referred to as false positives. *See also* Sensitivity
Stamping out	Disease eradication strategy based on the quarantine and slaughter of all susceptible animals that are infected or exposed to the disease.
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 of, 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, are 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 the 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 life cycle of the agent.
Vertebrate pest control officer	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 local area.
Wild animal control area	An area in which wild animals are (or are suspected to be) infected with an emergency disease agent or have the greatest risk of contact with infected domestic animals.
Veterinary investigation	An investigation of the diagnosis, pathology and epidemiology of the disease. *See also* Epidemiological investigation

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	Domestic animals that have become wild (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 or 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 disease-free and infected areas in accord with OIE guidelines, based on geopolitical boundaries and surveillance, in order to facilitate trade.
Zoonosis	A disease of animals that can be transmitted to humans.

Abbreviations

1080	sodium monofluoroacetate
AAHL	Australian Animal Health Laboratory
AHS	African horse sickness
ASF	African swine fever
AUSVETPLAN	Australian Veterinary Emergency Plan
BSE	bovine spongiform encephalopathy
CA	control area
CCEAD	Consultative Committee on Emergency Animal Diseases
CEM	contagious equine metritis
CSF	classical swine fever
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CVO	chief veterinary officer
CWD	chronic wasting disease
DAFF	Department of Agriculture, Fisheries and Forestry (Australian Government)
DCP	dangerous contact premises
EAD	emergency animal disease
EI	equine influenza
FMD	foot-and-mouth disease
GIS	geographic information system
GPS	global positioning system
HPAI	highly pathogenic avian influenza
ID	identification
IP	infected premises
JE	Japanese encephalitis
LDCC	local disease control centre
LSD	lumpy skin disease
ND	Newcastle disease
OIE	World Organisation for Animal Health [Office International des Epizooties]
PPR	peste des petits ruminants
PRRS	porcine reproductive and respiratory syndrome
RA	restricted area
RVF	Rift Valley fever

SGP	sheep pox and goat pox
SVD	swine vesicular disease
SWF	screw-worm fly
TGE	transmissible gastroenteritis
TSE	transmissible spongiform encephalopathies
VAI	virulent avian influenza
VE	vesicular exanthema
VS	vesicular stomatitis
WHO	World Health Organization

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