VERTEBRATE PESTS

vertebrate pests
OF BUILT-UP AREAS
in Queensland

PEST STATUS REVIEW SERIES - LAND PROTECTION

by
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Acknowledgments

The author acknowledges the generous assistance of Natural Resources and Mines, Land Protection staff. Thanks are also due to the many local government officers who have contributed observations and information. Dr Darryl Jones of Griffith University provided valuable insights on the human dimensions of pest animal problems. This assessment also draws upon information in the Bureau of Resource Science series of publications "Managing Vertebrate Pests".

Editorial contribution has been made by Clyde McGaw, Elton Miller, Dr. Peter Mackey and Claire Heath.

Cover and contents design:
Grant Flockhart and Sonia Jordan

Photographic credits:
Natural Resources and Mines staff

QRNM01032
ISBN 0 7345 1774 2
Published by Natural Resources and Mines, Queensland.

Land Protection
Natural Resources and Mines
Locked Bag 40, Coorparoo Delivery Centre, Q, 4151

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1. Summary

Built-up areas represent a special set of problems in the management of pest animals. With population increases in urban areas across Queensland and the growing fragmentation of the environment these problems are bound to increase in the future. It is therefore important that changes are made to improve our understanding of these pest problems and ways to manage them.

Pests of built-up areas consist of a mix of both introduced and native vertebrate species. Little is known about the ecology of some of these pest animals and this lack of information can make it difficult to plan effective responses. Pests in built-up areas have important social, economic, and environmental impacts; some impacts are readily understood and quantifiable but some are poorly understood or under appreciated. It is important to recognise that little is known about the impacts of vertebrate pests in core urban areas, as most data comes from the urban fringe; meanwhile, true core urban pests may be silently having a large impact.

Pest problems in built-up areas inevitably affect large numbers of people. In these circumstances, it may be difficult to obtain agreement on acceptable forms of pest management. There may be conflicting opinions in the community about the status of a species as a pest, or the acceptability of control methods. Pest managers who do not address the human dimensions of pest problems can become involved in community conflict. Providing communities affected by pest problems with good information, opportunities to discuss issues, and a method for resolving disputes will usually be a necessary part of establishing effective pest-management practices.

In many instances, pest control becomes reactive: a matter of maximising the number of pests killed rather than minimising impact. High human population density may restrict the use of the broad scale pest-management approaches routinely employed in rural areas due to proven or perceived hazards to people, animals that are not being targeted or the environment.

There is a general lack of understanding about where responsibility for managing pest problems lies. The administrative differences between undeclared and declared pests and the differences between native and non-native pests are often unclear to members of the public. In addition, people often have little appreciation of the practical necessity of being involved in solving their own or their community's pest problems. Affected groups or individuals typically complain but may not participate in problem-solving exercises.

Improving the response to pest-animal problems in built-up areas will require:

- the collection and dissemination of better knowledge on ecology, impacts and control
- improved community awareness of the nature of pest animal problems
- a sense of community responsibility for solving pest-animal problems
- cooperation between individuals, organisations and government agencies.

2. Pest Animals and Built-up Areas

In Queensland, pest problems in built-up areas have existed since its cities and towns were founded. Since there are a variety of animals present in and around the centres where most people live, humans and animals are constantly brought into contact. Inevitably, and not surprisingly, conflicts of various sorts are the result of many of these encounters.

Two interchangeable terms 'built-up areas' and 'urban areas' will be used in this document to describe areas of high human population density. These areas include residential land as well as industrial, commercial and conservation zones that lie within or on the edge of residential areas. Cities, towns and other highly urbanised environments, including holiday resorts, all fit into this definition. A second term 'urban fringe' refers to the areas of mixed residential and agricultural lands that border built-up areas. The urban fringe includes rural-residential settlements, for example hobby farms and small holdings, especially where these adjoin or encroach on undeveloped land or support extensive primary production. Urban fringe pest problems make a significant subset of the urban pest issues. Although many invertebrate pests such as cockroaches, termites and mosquitoes are called urban pests by the pest-control professionals who treat them, they will not be discussed in this review as they cause impacts only to individuals and they do not significantly affect the environment or production.

Vertebrate pests in built-up areas are chiefly those species which have strong associations with humans or have adapted to live near humans. Many have historically been bred and kept as livestock: for food, as working animals, or for companionship. Rabbits, for example, have been hunted in the wild for sport, raised for food and fur, and kept as pets. A major problem with built-up areas is the need to require consensus on control methods or that there is a problem from a large group of people that has differing experiences with animals to other groups.

2.1 What makes an animal a pest in built-up areas?

Urban pest animals belong to a variety of vertebrate taxa. There are approximately 75 exotic vertebrate species with established wild breeding populations in Australia: 30 mammal, 20 bird, 20 fish, and 5 amphibian species. Many of these have become established as pests in built-up areas in Queensland. In some circumstances, native animals may also be pests. While the approach for managing native wildlife is similar to that for introduced animals, it is usually more complex because of the need to balance conservation of the native species and reduction of its impacts.

Not all introduced animals are able to establish and maintain stable, wild breeding populations. The exotic species which are most successful are, in general, those that are suited to the climate, vegetation or landscape of the host environment, or that are highly adaptable. They are usually able to disperse effectively, and under favourable circumstances reproduce rapidly. These attributes favour their establishment in significantly altered or disturbed environments, especially where there may be many unfilled ecological niches and relatively little competition from native fauna.

In discussing vertebrate pests it is important to distinguish between organisms with pest potential and pest problems. This is necessary because animals with pest potential do not always create a pest problem. Further, many pest problems are a matter of human perception: what one person defines as a pest requiring eradication may be regarded by another as a creature worthy of protection (see chapter 5). In Queensland, such divergent opinions have hindered attempts to control foxes, flying foxes and deer. The distinction between pests and pest problems is especially relevant in the urban areas: large numbers of people may be potentially affected but only a small percentage are while others in the area may see the animals as desirable.

A vertebrate pest species is one that is known in some circumstances to cause one or more of the following outcomes:

- has a net negative impact on primary or other production
- has a negative impact on human health or safety
- directly reduces the sustainability of native flora or fauna populations, or the resources upon which these depend
- creates a nuisance that reduces the quality of life for a community.

A pest problem occurs if a species realises its potential to generate any of these impacts, or where it is perceived that this occurs. It is important to recognise that pest managers, particularly in urban areas, may be required to respond to situations where the cause and effect between the pest organism and the perceived or visible impact may have been incorrectly assumed or cannot be reliably established (Bomford, Newsome & O'Brien 1995; Perry 1999).

2.2 Differences between built-up areas and rural areas

Australia has a highly urbanised population. The most densely populated 1% of the continent supports 84% of the population while half the continental area supports only 0.3% of the population. Since the turn of the century, the proportion of the population living in rural areas has been declining, having decreased from 43% in 1911, to about 13% in 1996. Although Queensland is the most decentralised State, with only 45% of the population living in the Brisbane region, although approximately 81% of the population still lives in areas defined by the Australian Bureau of Statistics as urban (*State of the Environment Queensland* 1999). The State follows the national trend of declining rural populations, with the percentage living outside population centres declining from 17.1% in 1986 to 16.3% in 1996.

Urban areas differ from rural areas in several respects: property size, population density, land use, and the social attitudes of residents. These differences contribute to the need for different pest management regimes.

2.2.1 Property size and population density

Property size and population density differs markedly between urban and rural areas. Residential and recreational blocks of land, as well as agricultural properties, are generally smaller in more densely settled areas. Most urban blocks are relatively small, varying from the urban residential blocks of 0.05 ha to 0.2 ha to rural residential blocks of 0.2 ha to 4 ha (Regional Planning and Advisory Group 1993b). Blocks on the urban fringe used for small grazing, horticulture and mixed agricultural enterprises range from 3 ha to 800 ha (Regional Planning and Advisory Group 1993a, 1993b). This difference in size

may be seen in table 1, which compares the contributions that small properties make to the total land areas of sample rural and urban local government areas in Queensland.

Table 1. Contribution by small properties to total area of rural and urban local government areas

Local government area	Settlement pattern	<0.5 hectares	<1 hectares	<3 hectares
Rockhampton	Urban	6.95%	7.96%	10.55%
Livingstone	Rural	0.41%	0.71%	2.77%
Jericho	Rural	0.11%	0.87%	2.72%

Note: totals are cumulative

Source: Regional Planning and Advisory Group 1993a, 1993b

Queensland's average population density is 1.97 people per square kilometre but this conceals the large variations in regional population densities. The average population density in rural Queensland is 0.4 people per square kilometre, while in the City of Brisbane it is 715 people per square kilometre (*State of the Environment Queensland* 1999). The average density for coastal Queensland is 7.2 people per square kilometre but densities in coastal regions reach as high as 59.4 and 92.8 in Caloundra and Maroochy shires respectively.

High population density means that pests and pest management have impacts on more land owners, occupiers and managers than in an equivalent sized rural areas. For example, in figure 1, three boxes (diagonal stripes) representing the size of a typical rural fox territory are superimposed on a map showing properties in an area on the north end of the city of Caboolture, in south-east Queensland. The figure shows that as the property size decreases towards the centre of town (bottom left), many more properties and people are affected by the presence of a fox. This figure may overestimate the risk in the core urban areas, however, as the territory of urban foxes may be smaller due to the availability of better food sources allowing a greater density of foxes in this area.

2.2.2 Primary production in built-up areas

Most land use in built-up areas is either residential or commercial and so vertebrate pests do not have a direct impact on most land managers. Primary production in urban areas or in the urban fringe may, however, be of regional importance, and production for particular classes of produce may constitute a significant proportion of total State production. Some smallholdings produce high-value crops or livestock and pests may cause substantial economic losses.

Returns from agricultural production on the urban fringe have been considered to add only a small contribution to the economy and so broad scale pest management to safeguard agricultural production in these areas has been seen

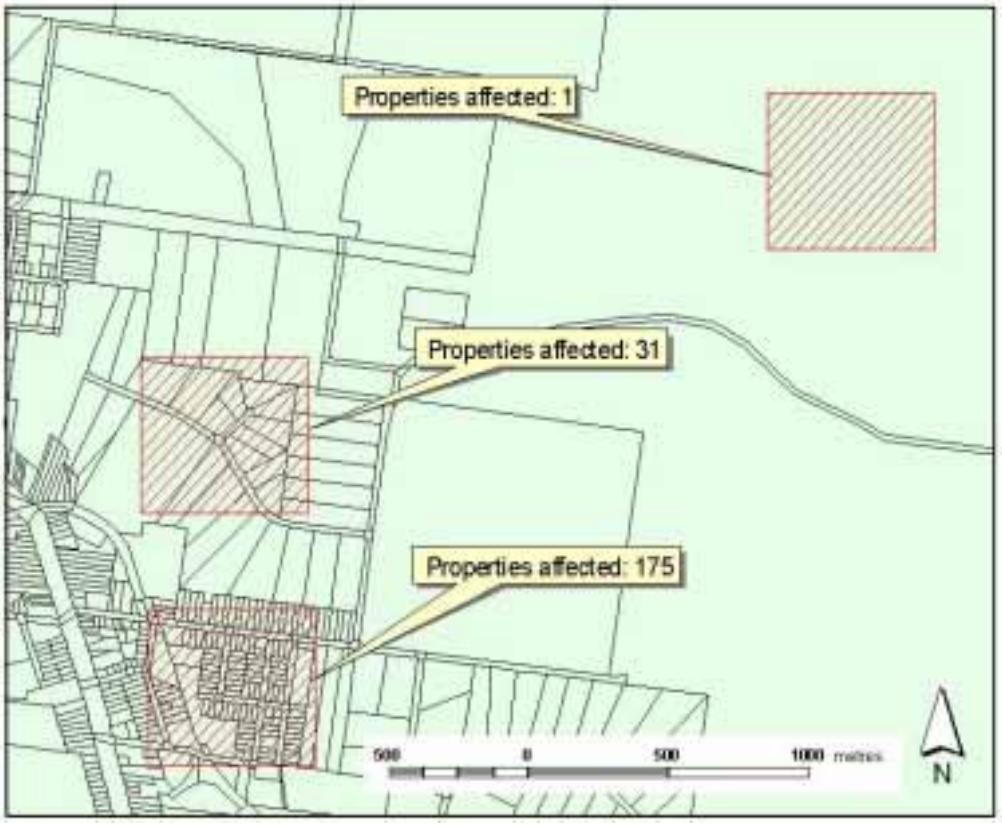

Figure 1. The impact of pests on landholders in urban and rural areas using the example of a fox territory on the edge of the city of Caboolture

as unwarranted. Table 2 demonstrates that the densely settled urban fringe production areas in the Moreton and Brisbane statistical divisions produce a large proportion of the fruits and vegetables grown in Queensland (36% in 1995–1996). These statistical divisions host a population of over 2.1 million people in a mix of urban areas and those used primarily for primary production (*State of the Environment Queensland* 1999).

Table 2. Agricultural production in statistical divisions in south and central Queensland

Statistical division	Sugar	Barley	Grain sorghum	Potato	Pineapple	Dairy cattle	Meat cattle	Sheep	Pigs
Moreton & Brisbane	199	165	196	148	160	659	3102	39	134
Mackay	1302	5	112	1	6	55	1096	3	16

Note: Figures are the number of properties in an area given over to the crop or product

Table 3 demonstrates that these agricultural enterprises operate on relatively small properties. In the statistical regions of Moreton and Brisbane, 64% of agricultural enterprises operate on properties of less than 100 ha. The statistical division of rural Mackay reflects the pattern for smallholdings outside the greater metropolitan area: 32% of agricultural enterprises are on properties of less than 100 hectares. Although many primary producers on the fringe would be able to employ the range of pest control measures, some would be constrained by restrictions on use such as controls on baiting within 5km of houses.

Table 3. Agricultural enterprises in Moreton–Brisbane and Mackay statistical divisions on properties of less than 100 ha

Statistical division	Number of enterprises	% of total enterprises
Moreton and Brisbane	3656	64
Mackay	718	32

2.2.3 The urban dweller

Social factors place constraints on pest managers in built-up areas. Progress in implementing pest-management programs may be slow since the actions of pest managers are open to greater scrutiny, by a public with varying experiences and mixed attitudes towards pest management (Jones et al. 1998). A large percentage of the population may not have any opinion or may be apathetic about pest issues. This apathy may stem from a number of causes including lack of direct knowledge or interest or not knowing they could play a role. Urban residents may not consider the risks of carrying out pest-control work are justifiable if people's livelihoods are not threatened by pests. Many pests in urban areas cause a transient nuisance. These nuisance issues may still be important to the people affected, however, and may require solutions or at least some form of recognition by pest managers or they will escalate.

It is certainly true that unrealistic expectations are placed on urban pest managers. For example, it is common for members of the urban public to demand control of a particular pest species, while at the same time rejecting use of the only effective control methods. A survey of public attitudes showed that most people believe current pest management to be inadequate (Johnston & Marks 1997), with more than half of the population believing foxes, for example, should be eradicated. However, only 12% of the population believes that the only really effective broad scale control measure for foxes, poisoning, should be used to achieve this aim. The social dimension of management will be discussed in chapter 5.

2.3 Built-up areas with persistent pest problems

2.3.1 The urban fringe

Vertebrate pest problems are chronic in the urban fringe. The fragmented landscape of these areas offer a mosaic of vegetation types and other resources that are used by pest animals. The urban fringe provides abundant food in the form of livestock, wildlife, crops, and refuse. Road kills are a readily available source of carrion eaten by animals such as foxes and wild dogs, which often forage habitually along landscape features such as roads.

Pest-management conflicts on the urban fringe are increasing, partly because of the rapid population growth in these areas, other reasons include changes in crops and the introduction of new pests. Population growth in rural residential areas in the 21 local government areas of south-east Queensland was estimated at 7.7% a year in 1991. The rural residential population accounts for 5.3% of south-east Queensland's population (*State of the Environment Queensland* 1999).

Many primary producers on the rural fringe have in the recent past allowed domestic animals, particularly dogs and cats, to roam freely. However, as urban centres have grown, substantial numbers of people have moved into rural residential developments to enjoy a lifestyle that has some of the aspects of living in the country. Many of the problems with pest species in these areas may be due to different perceptions about and knowledge of pests between the people who now live in the urban fringe rather than differences in impacts of pest species. For some of these new settlers, living in a rural-residential area means enjoying a landscape which is relatively unspoiled, and populated with a variety of wildlife for which they feel great affinity. These people often object to established rural community practices, which they believe are detrimental to fauna and the environment generally (e.g. allowing domestic animals to roam).

Owners who let their dogs roam often believe that attacks on livestock in rural areas are made exclusively by packs of wild dogs. This is a fallacy. Most attacks on livestock are carried out by single dogs or pairs, as shown in a study of 1,400 dog attacks on livestock in the Perth area (Jennens 1998). In this study it was shown that only 9% of attacks were carried out by three or more animals. Also, 80% of dog attacks were carried out by animals owned by neighbours or other producers who lived less than half a kilometre from the attack site. For rural-residential dwellers and primary producers on the urban fringe, it is likely that dogs owned by neighbours therefore pose the greatest risk of attack.

2.3.2 Small coastal settlements

Small coastal settlements surrounded by hinterland that includes large tracts of State forest, national park or other State land, often experience recurring pest problems, more so than areas of single land use or dense development. The town of Burrum Heads, near Maryborough, is a small residential area which has experienced recurring problems with wild dogs that live in adjacent protected or inaccessible areas (figure 2). The dogs roam through the town and feed on rubbish and offal left by recreational fishers. The situation is aggravated by a small number of residents who attract the animals by deliberately feeding them. Pets are sometimes taken, and the residents fear that the dogs, which are apparently habituated to people, will attack a child after recent injury to pest in other areas (Raguse 2000; Ryan 2000).

Other areas are affected in similar ways by deer, pigs and rabbits. The residents of small communities such as this often feel that pest problems cannot be adequately managed because they are either legally constrained from carrying out control work in land adjacent to their towns or because control would be impractical over the required (large) areas. Management of these pest problems is possible but would involve a greater degree of public input and review of management of government land.

2.3.3 Conservation reserves

In urban areas, where landscape modification has been extensive, most areas of remnant ecosystems are considered to have high conservation value (Catterall & Kingston 1993). Small fauna populations in remnant ecosystems, whether they are formally conserved or not, may be particularly vulnerable to predation by or competition from pest animals. This is because remnants frequently support lower numbers of fauna, and these populations are less resilient to chance events and external pressures (Burbidge & McKenzie 1989;

Hansson 1991) in the same way that populations that are naturally isolated, such as those on islands, are prone to extinction (Diamond 1975). Examples of this problem from other States include the decline of bandicoots in the bushland reserve in Sydney's north as a consequence of pressures including predation by feral and domestic animals, and road trauma. Concern over the loss of lyrebirds in Sherwood Forest, Victoria, sparked a vigorous public debate on the presence of cats and dogs in bushland reserves.

In fragmented landscapes strands of vegetation, particularly in riparian areas, are retained to provide ecological connectivity between fragments. However, if this vegetation constitutes movement corridors for native fauna, there is no reason to suppose that it will not also facilitate the movement of pest animals. This has the potential to increase the impacts of predation in remnant bushland. Reserves in built-up areas can also harbour pest animals, and corridors can facilitate the movement of pests out into the residential or fringe areas (figure 2).

2.3.4 Industrial areas and undeveloped land

It is possible to find substantial areas in large urban zone where few people live, and where landscape maintenance is less intensive than in the neighbouring residential areas. Pockets of undeveloped or wastelands, industrial complexes, low-lying or poorly drained areas, rubbish tips and the buffers around airports and seaports often support sizeable populations of pest animals. These areas are also frequently used as dumping grounds for unwanted domestic animals; for example the Port of Melbourne is known to be home to a large population of foxes (Marks & Bloomfield 1999b). One risk these pests pose is that they are vectors for serious diseases such as rabies (Marks & Bloomfield 1999a, 1999b). This is a serious concern in areas in and around international entry points, such as airports and seaports. (Disease risks are discussed in chapter 4.)

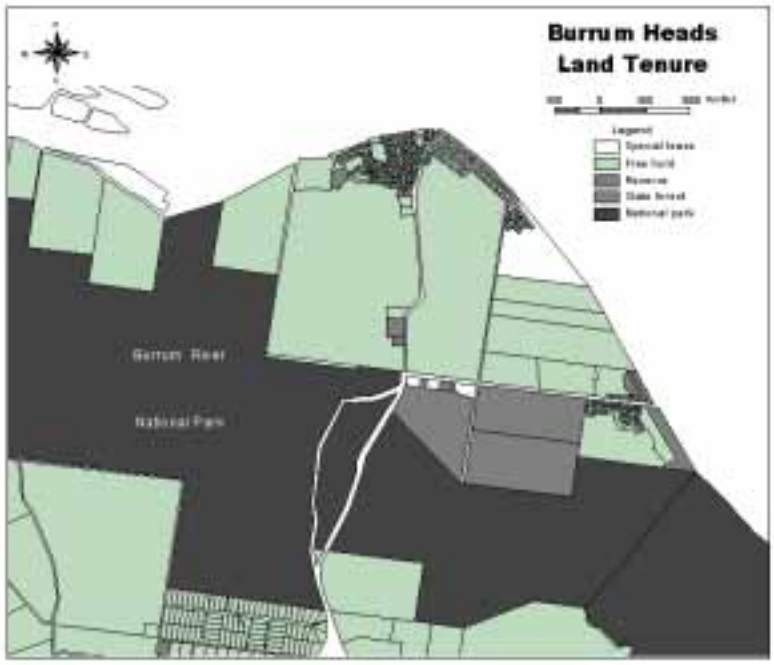

Figure 2. Wild dogs are a problem in the town of Burrum Heads on Queensland's south coast; the proximity of national parks and reserves to the small community increase the interaction between wild dogs and the community

3. Significant Pests of Built-up Areas

3.1 Introduction of vertebrate pests

Most of Australia's serious animal pests were deliberately imported as pets, curiosities or for food. Table 4 catalogues the reason for and date of most of these introductions. Many animals became established as pests following the accidental escape of livestock that subsequently established wild populations, and continuing escapes by domestic animals would have augmented wild populations. In the nineteenth century, acclimatisation societies imported and released animals for sport or to make new European settlers feel more at home in unfamiliar surroundings. European foxes, for example, were released in Australia in Adelaide (1869) and Victoria (1871), and by 1910 they had become established across southern Australia and north to southern Queensland (Saunders et al. 1995).

Some pest species have been imported accidentally. One of these is the house mouse, which arrived on the ships with early European settlers and has since spread over most of Australia wherever there are suitable foods, chiefly grains (Strahan 1983). The brown rat and the black rat were also inadvertently brought to Australia in vessels. Both species have become established pests, with the former being largely confined to population centres (Strahan 1983).

3.2 Significant pests

In a recent survey, pest-management experts across Queensland listed 23 species of animals, including four native species, as being significant pests in built-up areas in Queensland (O'Keeffe 1999). The distribution and abundance and importance of each species as a pest varies from location to location. Of the pests identified (table 5), nine are declared under the *Rural Lands Protection Act 1985*. Queensland's current vertebrate pests are presented in table 5.

3.2.1 Cats

Domestic cats originally accompanied Europeans to Australia as companion animals. In the early years of colonisation, cats were confined largely to population centres, but the species rapidly established feral populations, aided by the deliberate release outside settlements for the purpose of controlling rodents (Rolls 1969). Most of the spread of cats occurred in the nineteenth century and populations may now be stable. Cats are also kept as domestic pets, and it was estimated in 1988 that 1.8 million Australian households own 2.6 million cats (Australian Veterinary Association 2000). There are an estimated 460,000 owned cats in Queensland. The number of stray and feral cats has not been estimated; however, cats are found in all environments, including arid regions. Although feral cats are solitary animals, population density can exceed 1 animal per km^2 in favourable habitats. The home range of adult feral cats can be as much as 8 km^2 (Strahan 1983).

Table 4. History of exotic vertebrate introductions in Queensland in order of first occurrence

Common name	Scientific name	Date of arrival in Queensland	Comment on introduction
Dog	*Canis familiaris dingo*	10,000 years ago	Date indicated by earliest known fossil record
Cat	*Felis catus*	About 1800	Possibly arrived earlier
Black rat	*Rattus rattus*	Early 18th century?	Arrived with First Fleet
Horse	*Equus caballus*	1840s	Arrived with First Fleet
Starling	*Sturnus vulgaris*	About 1850	Introduced by naturalisation society
Goat	*Capra hircus*	1860s	Arrived with First Fleet
House sparrow	*Passer domesticus*	1863	Introduced by naturalisation society
Feral pig	*Sus scrofa*	1865	Arrived with First Fleet
Myna	*Acridotheres tristis*	1883	Introduced in 1862 by naturalisation society
Rabbit	*Oryctolagus cuniculus*	1886	Domestic with First Fleet; wild rabbits arrived in 1859
Feral pigeon	*Columba livia*	1873	Introduced by naturalisation society
House mouse	*Mus musculus*	Late 18th century?	Arrived with first Europeans
Brown rat	*Rattus norvegicus*	Late 18th century?	Arrived with first Europeans
Hare	*Lepus capensis*	Late 18th century?	Established after 1862
Fox	*Vulpes vulpes*	1910	Released for sport 1871
Red deer	*Cervus elaphus*	1914	Released for food
Cane toad	*Bufo marinus*	1935	Released as biocontrol agent

Disagreement exists over the impact of cats; it is based mostly on a lack of recognition of the differences in behaviour and ecology between cats with three different degrees of dependence upon humans. These are:

- domestic cats, which live in close association with humans, who supply their needs
- stray or unowned cats, which rely partly on humans for shelter or food that may be deliberately or unintentionally supplied
- feral cats, which do not rely on humans for any of their ecological needs, and which have free-living populations that self-perpetuating.

A wide range of native and exotic pests is recorded as being taken by cats (Paton 1993; Amarasekare 1993; Courchamp, Langlais & Sugihara 1999). There is substantial evidence that cat predation has negative impacts on native fauna in remote or relatively undisturbed environments, especially islands, where cats have caused extinctions (Karl & Best 1982; King 1984; Dickman 1996). The impacts of cats on urban fauna can not be presumed to be as dramatic, although sufficient evidence exists to show that a reduction in the number of stray cats in built-up areas benefits native fauna (Tidemann 1994).

Table 5. Status of built-up pest species under the Queensland *Rural Lands Protection Act 1985*

Species	Status under the Act	Notes
Acridotheres tristis (Indian myna)	Not declared	No statutory requirement to control, control not prohibited
Bufo marinus (cane toad)	Not declared	No statutory requirement to control
Canis familiaris (domestic dog)	Not declared	Mammals normally living in domestic situations not declared; any stray dog may be destroyed under s. 236; keeping is subject to local laws
C. familiaris dingo (dingo)	A1, A3, A5	Introduction, keeping, selling prohibited; numbers to be reduced and restricted; protected in national parks under *Nature Conservation Act 1992*
Capra hircus (goat)	A2, A4, A6	Must be destroyed; introduction, keeping and selling subject to conditions
Columba livia (rock dove or feral pigeon)	Not declared	No statutory requirement to control
Corvus orru (torresian crow)	Not declared	Protected under *Nature Conservation Act 1992*; cannot be killed or 'taken' except by permit under a regulation
Equus caballus (feral horse)	A2, A4, A6	Must be destroyed; introduction, keeping and selling subject to conditions
Felis catus (cat, domestic and feral)	Not declared	No statutory requirement to control
Gymnorhina tibicen (Australian magpie)	Not declared	Protected under *Nature Conservation Act 1992*; cannot be killed or 'taken' except by permit under a regulation
Lepus capensis (hare)	A1, A2, A3	Introduction prohibited; exotic, must be destroyed; keeping and selling prohibited
Mus musculus (house mouse)	Not declared	
Mustella putorius (ferret)	A1, A2, A3	Introduction prohibited; exotic, must be destroyed; keeping and selling prohibited
Oryctolagus cuniculus (rabbit)	A1, A2, A3	Introduction prohibited; exotic, must be destroyed; keeping and selling prohibited
Passer domesticus (house sparrow)	Not declared	No statutory requirement to control
Paco cristatus (peacock)	Not declared	No statutory requirement to control
Pteropus spp. (flying foxes)	Not declared	Protected under *Nature Conservation Act 1992*; cannot be killed or 'taken' except by permit under a regulation
Rattus norvegicus (brown rat)	Not declared	No statutory requirement to control
Rattus rattus (black rat)	Not declared	No statutory requirement to control
Rattus sordidus (canefield rat)	Not declared	Protected under *Nature Conservation Act 1992*; cannot be killed or 'taken' except by permit under a regulation
Sturnus vulgaris (starling)	Not declared	No statutory requirement to control
Sus scrofa (feral pig)	A1, A2, A6	Introduction prohibited; exotic, must be destroyed; keeping and selling prohibited
Cervus spp. (deer)	Not declared	
Vulpes vulpes (red fox)	A1, A2, A3	Introduction prohibited; exotic, must be destroyed; keeping and selling prohibited

Cats may be a significant nuisance to humans in built-up areas. They may transmit diseases that affect humans; for example toxoplasmosis is a potential hazard to pregnant women (Hartley & Munday 1974). Local governments devote considerable resources to cat control as domestic and stray cats are a source of noise, odour and property damage. One example is of a house in Cairns that was home to 40 abandoned cats; when the building was demolished the animals became a nuisance throughout the neighbourhood, requiring them to be trapped (Low 2000). Some local governments require cats to be licensed (Anon 2000a), and some northern shires support the introduction of a $2 bounty to help control feral cats (Anderson 2000).

Urban cats typify urban pest issues in which management has a significant social component. Reduction of the impact of domestic and stray cats is overwhelmingly a matter of changing human behaviour, which would result in people take responsibility for helping to control cat numbers.

3.2.2 Feral pigs

Feral pigs, which were introduced in the last 150 years, are the most significant mammalian pest of agriculture in Australia. They inhabit a variety of natural and modified environments: forests, wetlands, agricultural land, and derelict and industrial land and reserves in urban areas. In Queensland, they are most common in swamps and large drainage basins. Population densities range from 0.1 to 40 animals per km^2 (McGaw & Mitchell 1998).

Pigs cause impacts to agriculture: grain crops, pasture, sugar cane, fruit; including pineapple, bananas, melons, citrus and strawberries, vegetable crops and stock losses (McGaw & Mitchell 1998). Although most of the damage feral pigs cause is to agricultural equipment and infrastructure and to water supplies, they may cause some damage to gardens and property in urban areas. The presence of feral pigs will most often draw a strong response from members of the public who regard the animals as a personal safety risk (Harvey 2000). Pigs may carry both exotic and endemic diseases.

3.2.3 Wild dogs

Wild dog is a term used to include the domestic dog (*Canis familiaris* ssp. *familiaris*) that is either unowned or free roaming, the pure dingo (*Canis familiaris* ssp. *dingo*) or a hybrid of the two. This term is used because there are profound difficulties in rapidly differentiating pure bred dingoes from hybrids and because most dingoes in or near built-up areas are hybrids. The survival of the dingo as a distinct form of dog is threatened by hybridisation with free-ranging domestic dogs. Dogs are now more abundant than at the time of European settlement because of the increased availability of water and prey, such as rabbits, and naturalised domestic dogs continue to supplement wild dog populations. Wild dogs are found throughout Queensland; home ranges and densities of dogs vary according to the productivity of the landscape.

Urban areas provide wild dogs with a range of animal prey, both introduced (e.g. sheep, goats, rabbits and calves) and native (e.g. macropods and possums). Dogs also scavenge from rubbish tips and other places where edible material accumulates. Increases in sightings of wild dogs can often be attributed to people feeding animals, with the result that the animals become less timid and are more readily observed by others. While there is no doubt that wild dogs

take some livestock and pets on the urban fringe, the magnitude of the problem is difficult to gauge as little data has been compiled in Queensland.

Domestic dogs were found to be the cause of both wildlife and livestock deaths in Perth (Jennens 1998) and are responsible for a large proportion of cassowary deaths in the tropical lowlands (Crome & Moore 1990; Pavlov 1997). Domestic dogs, like domestic cats, can be a significant nuisance to humans in built-up areas. Considerable resources are devoted to dog control by local governments, as domestic dogs are a source of noise, damage to property and, at times, threaten human health when pets attack owners or strangers (Raguse 2000).

3.2.4 European red foxes

The European red fox is an adaptable predator that has colonised most of Australia except for the tropical north, and Tasmania and other islands. Foxes avoid large areas of uniform vegetation cover, especially heavily timbered country and unbroken open areas. They are present in most urban areas, apparently preferring derelict land, overgrown gardens, parks and cemeteries with patches of dense vegetation (Saunders et al. 1995). Disused and inhabited buildings are used for shelter, as are discarded pipes, industrial equipment and timber heaps. Fox densities may be as high as 16 animals per square kilometre in urban areas (Marks & Bloomfield 1999a), but are generally much lower in rural areas (Saunders et al. 1995).

Foxes have no specialised food requirements. They are primarily carnivorous, taking live prey and carrion but also consume vegetable matter. A variety of small native and exotic fauna is taken (Thompson 1983; Burbidge & McKenzie 1989; Scott, Mume & Dickman 1999). In urban areas they readily scavenge for food scraps, pet food and refuse. Ecological studies, including fox-removal experiments, have indicated foxes as a major contributor to the decline of native animals including the rock wallaby, bettong, numbat, mallee fowl and sea turtle (Anon 2000b). Most commercial poultry is housed in fox-proof enclosures but hobby farmers and small-scale free-range poultry keepers may incur losses.

Foxes can transmit diseases that infect humans and livestock. Of greatest concern is the potential for foxes to carry rabies, should the disease arrive in Australia. In areas where rabies is endemic, foxes are important hosts, and fox control is central to managing the disease (Saunders et al. 1995).

3.2.5 Rabbits

Rabbits were introduced to Australia from Europe with the First Fleet and now occupy about 60% of the land area of Australia at varying densities (Williams et al. 1995). Rabbits first appeared in Queensland in about 1886 (Stodart & Parer 1988). They are now found in the southern half of the State, and are most abundant in the Granite Belt. Population densities can vary significantly depending on the season and the impact of biological controls.

Rabbit damage is localised in most built-up areas in Queensland. Rabbits can damage grain, vegetables, fruit or ornamental trees and they have the potential to cause considerable damage in suburban and public gardens. Of concern to pest managers is the possibility that small colonies in urban areas may expand. In the Gympie area, for example, rabbits have become established in the yards

of several timber mills. The animals are thought to have been brought to the area in logs transported from west of the rabbit proof fence.

Rabbits are not abundant in most urban areas in Queensland. There is public confusion over their pest status as although they are declared; some people want to keep them as pets (O'Keeffe 1999). Nevertheless, a recent Victorian survey on pest-animal issues (Johnston & Marks 1997) showed that 61% of respondents defined rabbits as a pest, and 56% of respondents favoured their eradication. Only 1% believed no control should occur.

3.2.6 Brown hares

Brown hares were introduced from Europe for hunting and coursing in 1862. They are now widespread and common in grassland, woodland, agricultural land, urban parks and bushland in eastern Australia, including Queensland (Strahan 1983). Unlike rabbits, for which they are often mistaken, hares do not burrow; rather, they rest by day in forms, shelters made of grass or other vegetation under rocks or in shallow scrapes on the ground. Hares are able to breed rapidly, having as many as six litters of between two and five young per year, but they do not spread a rapidly as rabbits. Densities of 1.9 hares per ha were measured in Brisbane suburbs (Finch, McBrien & Jones 2000).

Hares graze mostly on grasses, but may opportunistically feed on vegetables, plants in nursery and market gardens, and on cereals and fruit trees. Hares may cause local damage in orchards by ring barking trees or by browsing in areas planted to small trees.

3.3 Minor and emerging pests

A number of native and exotic vertebrate animals are increasingly demonstrating pest potential or pest problems in urban areas of Queensland.

The cane toad (*Bufo marinus*) was released as an early experiment in biological pest control in north Queensland in 1935 in the expectation that it would reduce numbers of frenchi beetles and grey-back cane beetles, both pests of sugar cane. However, the toads themselves have become a pest: by 1945, cane toads had colonised a large area, and had reached Brisbane (Natrass 1995), and they now occur from Sydney to the Northern Territory. They are known to consume native fauna, including frogs, and native predators such as quolls, goannas and snakes can die if they eat cane toads (Freeland & Kerin 1988). Recently, epidemiological research into widespread amphibian declines in Australia have indicated that cane toads may be implicated in spreading a chytrid fungus that is lethal to native frogs (Berger, Speare & Hyatt 1999).

The axolotl or Mexican walking fish (*Ambystoma mexicanum*), which is often available in pet shops in Queensland, has also been implicated in the spread of the fungus (Berger, Speare & Hyatt 1999). It has not naturalised to date.

Several species of deer are found in Queensland but most species are not found near urban areas. The red deer (*Cervus elaphus*) is present in the Brisbane and Mary river watersheds where it affects grazing land, crops and plantation trees. Deer may also harbour cattle ticks if they are closely associated with stock, and so are a risk for tick control programs.

The common or Indian myna (*Acridotheres tristis*) first released in Melbourne in 1862 (Long 1981), was released in Queensland in 1883 at Herberton, Johnstone River and Townsville in the hope that it would control insect pests in cane fields (Frith 1979). They have since established in built-up areas and agricultural lands (Pell & Tidemann 1997b; Martin 1996). In some built-up areas large, noisy roosts of many thousands of birds have been recorded (Wood 1995), causing a significant nuisance to adjacent areas. There is some evidence that mynas may have adverse impacts on native cavity-dwelling fauna, particularly parrots (Lindenmeyer 1993; Pell & Tidemann 1997a, 1997b).

The mallard (*Anas platyrhychos*) is a northern hemisphere duck that was first introduced to Australia in the 1860s and again in the twentieth century. Mallards can interbreed with the native pacific black duck (*Anas superciliosa*), producing fertile hybrids which show a preference for towns and gardens. This hybridisation is considered a significant threat to the genetic integrity of the native duck. Similar problems have occurred with European waterfowl following the introduction of closely related American species. Costly, unpopular culling of the exotic species has been undertaken to ensure survival of indigenous waterfowl in Europe (Lawson 1996).

Numerous native bird and mammal species are considered urban pests. In many cases the problems with these animals is related more to public perception and nuisance than to significant damage to humans or to agriculture. Depending on the season or area, ibises, magpies, crows, rainbow lorikeets, several species of flying foxes and possums can cause problems. Little research has been carried out on the impacts of most of these animals although some that has will be more fully discussed in chapter 5.

Examples of native pests in urban areas include the Australian white ibis (*Threskiornis molucca*), the only large wading bird to have adapted to living near humans. These birds forage for food in tips and parks and are a nuisance in areas such as the Gold Coast and Brisbane City (Lowe 1999). Flying foxes (various members of the genus *Pteropus*) have long been a nuisance for primary producers and urban dwellers because they eat crop fruits such as lychees and backyard mangoes and roost in large noisy and smelly colonies. With the knowledge that they carry human arboviruses (Mackenzie 1999) flying foxes have also become a human health risk and issue of concern in some towns. Mareeba Shire Council spent more than $7,000 in 2000 on fogging and other measures to move roosting colonies from the town (Blakesley 2000).

3.4 Potential pests

Population centres are major conduits for the entry and establishment of new vertebrate pests. Animals with pest potential are already kept in zoos and private collections, and there is a substantial international trade in exotic animals as pets and exhibits. This movement can result in the spread of disease, extinction in the area of origin and the establishment of new pests. In an attempt to forestall these problems, trade is regulated at international, national and State levels (see chapter 7 for more detail). The Indian palm squirrel (*Funambulus pennanti*) is one example of a zoo animal that has escaped from zoos in Sydney and Perth; feral populations have become established in suburbs around the zoo in Perth.
Some animals that are popular pets overseas have the potential to become serious pests that affect agriculture, the environment or both. One of these, the

golden hamster (*Mesocricetes accuratus*), is sold in North America as a pet but is prohibited in Australia due to concerns over its ability to establish wild populations if introduced. It is also considered a serious risk as a rabies vector. One species already present in Australia, the ferret (*Mustela putorius*), is a popular pet and may be kept legally in States including New South Wales, but is considered too high a risk to be permitted in Queensland.

Parrots, parakeets and lorikeets are very popular with bird collectors and there is worldwide trade (both legal and illegal) in these birds. Several species in this group of birds, such as the African rose-ringed parakeet, have serious pest potential. These species are currently common in private aviaries in Queensland and although they have not yet established in the wild, there is concern that they may escape and form breeding populations in the wild.

4. Impact

Pest animals have significant social, economic and environmental impacts. These will vary in type and extent with species and lands use. Some impacts, such as bird strike on aircraft, are readily quantifiable and well understood, while others, such as environmental impacts of some pest animals, are poorly understood and have not been well quantified. Some social responses to pests, for example nuisance issues such as noise, may be a matter of perception or awareness but have the potential to create passionate disputes in the community. The potential for significant animal impacts is demonstrated in the United States where incidents involving wildlife (both native and exotic animals that are not necessarily pests) result in an estimated 75,000 injuries and 415 deaths a year (Conover et al. 1995). It is important to note that this risk is mostly from native animals and consists of 35,000 bites from snakes, rodent and foxes; 29,000 injuries from deer–vehicle collisions; and 12,000 illnesses due to disease for which wildlife is the vector. The estimated costs approach US$ 3billion.

4.1 Diseases and parasites

In Queensland, urban pests pose a significant threat to human health, the productivity of livestock industries and the health of native fauna through being potential carriers, or amplifiers, of many native and exotic diseases.

Most parasites and pathogens affect more than one host group. Relationships between host groups may be complex and are moderated by a variety of factors that affect the prevalence and spread of disease within and between host groups. Because pest animals are generally species which have a close relationship with humans, they provide important epidemiological contact between wild animals, livestock and humans. While a particular pathogen may have greatest observable impact in one species (e.g. livestock), pest animals may be minor hosts for the pathogen and responsible for its continuation in the population or its transfer to other organisms. Figure 3 shows the interrelatedness of the ecological relationships between urban pests and parasites. The dark shading in the middle of the diagram indicates the highest risk group of pathogens and parasites, those that are carried by wild and domestic animals and that may affect humans.

The emergence of a number of new diseases and re-emergence of established ones has been linked to changes in the prevalence of pest animals and natives, and with increased contact with humans. These are due to the transformation of landscapes, increases in human population, changes in agricultural practices, increased movement of humans and animals, and the spread of urban areas. Disease outbreaks linked to urban pests include the re-emergence of leptospirosis linked to dogs and rats (Vinetz et al. 1996; Binder & Mermel 1998; Ko et al. 1999); and outbreaks of two paramyxoviruses, menangle and hendra, that are carried by flying foxes in Queensland and northern New South Wales and that affect pigs, horses and humans (Mackenzie 1999).

The diseases linked to pests that pose the greatest threat are listed in table 6. Of the exotic diseases, foot and mouth disease is thought to have the greatest potential for economic harm in Australia (Henzell, Caple & Wilson 1999). It is thought that if this disease gained entry to Australia, it might spread via feral cattle, buffalo and pigs. Pigs, in particular, are a concern because of their occurrence in built-up areas. This disease has been shown to be a highly

contagious as demonstrated by outbreaks in Europe in 2001. The other highest risk disease is rabies, a virus that can infect any warm-blooded animal. Australia and Antarctica are the only continents where the disease is not endemic. Dogs and foxes are important vectors; urban rabies is transmitted chiefly by dogs (Kaplan 1985). In developed nations, urban rabies is generally well controlled through large-scale animal vaccination and prevention programs. The control of stray dogs has been a cornerstone of this control. Nevertheless, 90% of human fatalities from rabies are attributed to dogs (Fekadu 1991).

Note: The high risk pathogens are where the three circles overlap
Source: Adapted from Daszak, Cunningham & Hyatt 2000

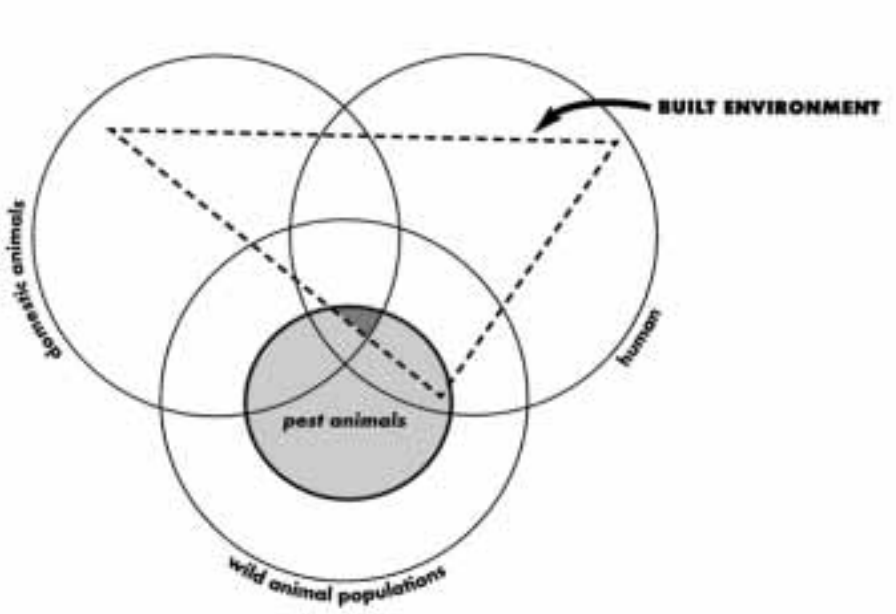

Figure 3. Links between pathogens and parasites in different animal host groups, and their effect on the built environment

Exotic diseases and pathogens may have significant impacts on native fauna in built-up areas. The impact of cats as agents of disease transmission has been studied more thoroughly than for other pest animals and there is strong evidence that two pathogens harboured by cats have serious impacts on native animals. The first, *Spirometra erinacea,* is a tapeworm, an intermediate stage of which can infect native rodents, frogs, carnivorous marsupials, monotremes, and snakes. The tapeworm causes sparganosis, a condition that damages lungs and muscle tissue and can be fatal (Dickman 1996). Symptoms of the second pathogen, toxoplasmosis (*Toxoplasma gondii*), include ungainliness, lethargy, loss of general condition and, sometimes, blindness. At least 30 species of native mammals and several species of birds have shown signs of infection, and there is speculation that toxoplasmosis is implicated in the decline of vulnerable species of native carnivorous marsupials, bandicoots, rodents and small macropods (Freeland 1994; Oakwood & Pritchard 1999).

The endangered gouldian finch (*Erythrura gouldiae*) has been colonised by air-sac mites thought to have been introduced by escaped caged birds (Tidemann 1992). This demonstrates the possibility of pest or disease transmission via exotic animals that escape and become established in the wild.

Table 6. Exotic and native diseases that can be carried by pests in built-up areas

Exotic diseases	Native diseases
Foot and mouth disease	Brucellosis (*Brucella* spp.)
Rabies	Tuberculosis (*Mycobacterium* spp.)
Aujeszky's disease	Leptospirosis (*Leptospira interrogans*)
Japanese encephalitis	Hydatid cyst (*Echinoccis* spp.)
African swine fever	Melioidosis (*Pseudomonas pseudomallei*)
Newcastle disease	Sparganosis (*Spirometra erinacei*)
Trichinosis	Murray Valley encephalitis
Rift Valley fever	Q fever
Vesicular stomatitis	Cat-scratch disease
	Arboviruses
	Paramyxoviruses
	Toxoplasmosis (*Toxoplasma gondii*)

4.2 Agricultural impacts

The agricultural impacts created by pest animals in built-up areas are generally localised (though sometimes intense), rather than extensive. This is because settled areas consist of a diverse mosaic of land uses and agricultural areas. As indicated by table 2, a wide range of agricultural businesses may be affected by pests in built-up areas or on the urban fringe.

4.2.1 Livestock predation

Predation by some pest animals has an important impact in some animal husbandry enterprises in the urban fringe (Coman 1985; Jennens 1998).

Wild dogs or roaming domestic dogs may take a variety of stock. Jennens (1998) found that over a 3 year period, 5,400 sheep, goats, cattle and horses were taken by dogs from over 1,300 properties. The study also showed that the extent of predation over seven Perth local authority areas was probably underestimated because of low reporting rates: only about 60% of attacks had been reported to local authorities. Livestock attacks include the cost from loses in milk production, mismothering and abortion. The loss of single animals may also represent a significant cost when unusual or rare livestock, such as llamas, alpacas, ostriches and heritage animal breeds, are kept.

The impact of foxes on goat herds may be serious, as fox predation on kids can be high (Saunders et al. 1995). Occasionally, foxes are a significant problem on emu and ostrich farms. A variety of poultry are popular as livestock on the urban fringe and in densely urbanised areas where local laws allow. Free-range poultry are relatively easy prey for foxes and most fowl taken by foxes are from hobby farms and small properties (Saunders et al. 1995).

4.2.2 Crop damage and other impacts

Vegetable, grain, horticultural and sugar crops grown in relatively densely settled areas may be damaged by some pest animals. Feral pigs are a serious pest of a variety of fruit, vegetable and grain crops grown in these areas (McGaw & Mitchell 1998). Feral pigs also damage small trees in forestry

plantings, by uprooting and trampling them while foraging in the soft ground created during planting.

Feral pigs also cause considerable damage to sugar cane crops, primarily in the tropics. Cane production occurs close to urban development and pig problems are likely to increase as urban development expands. (For example it is expected that as much as 20% of cropland in the Cairns and Sunshine Coast areas will be given over to urban land uses in the next decade.) The percentage of sugar crop losses has increased since 1961, when records were first kept.

Pest animals compete with livestock for forage, water and other resources (Williams et al. 1995), although little is known about these impacts in built-up areas. Pest animals may damage fences, netting, irrigation pipes and fixtures, and may cause injuries. For example, pest animals such as rabbits, which burrow, create opportunities for livestock to break or otherwise injure legs. No data collection has been made on these impacts to date.

4.3 Environmental impacts

Pest animals may generate a number of significant environmental impacts but on the whole urban pests have been very poorly studied and most of the knowledge about their impact is anecdotal. For example while there is strong evidence to suggest that domestic animals are important predators of wildlife in built-up areas (Paton 1991; Dowling, Seebeck & Lowe 1994; Meek 1999; Scott, Mume & Dickman 1999), the few studies of fauna predation suggest that declines in native fauna are not solely due to pest animal predation. Pest animals may be significant or even critical sources of impact in some circumstances (Barratt 1997) but other factors, such as habitat destruction and modification (Lynch 1987; May & Norton 1996; Sewell & Catterall 1998), genetic isolation (Merriam 1991; Fahrig & Merriam 1994) and road trauma (Scott, Mume & Dickman 1999) also contribute to fauna decline in built-up areas.

Through their feeding and other behaviour, some pest animals cause changes to vegetation, and the structure and integrity of the environment. These changes may be very localised or may affect the landscape on a very broad scale. A renowned example of the latter is the destruction of indigenous vegetation by rabbits (Williams et al. 1995). Urban landscapes, however, are a mosaic of land use types with varying degrees of disturbance and so, in general, the capacity for pest animals to modify built-up areas is overshadowed by the human-induced changes. It is thus difficult to discern landscape changes wrought by pest animals in any but the most unchanging parts of an urban area.

Through deposition of faeces, dogs, cats and other feral animals are sources of nutrient enrichment in bushland and waterways. Native and introduced birds also spread plant seeds, including those of weeds. Species such as blackbirds (*Turdus merula*), red-whiskered bulbuls (*Pycnonotus jocosus*) (Blakers, Davies & Reilly 1985; Ford 1989) and Indian mynas consume and spread the soft fruits of exotic plants.

In general, competition between exotic and native animals is very poorly understood in built-up areas. Pest animals compete with native fauna for food, water and living space, and in some instances exotic species may displace natives. Carnivorous mammals such as foxes, dogs and cats are potential competitors of native carnivores such as quolls and predatory birds, although, in

the absence of quantitative evidence, the degree of competitive impacts of exotic carnivores remains speculative (Dickman 1996).

There is more data on competition between introduced birds and native fauna; for example Indian mynas compete with native cavity-dwelling birds and mammals (Pell & Tidemann 1997a, 1997b; Peters & Peters 1993; Martin 1996). A limited number of studies show that built-up areas support bird groups with proportionally more exotic species and at higher densities than the bird communities they replace (Jones 1981; P. Woodall 2000, pers. comm., 8 June).

4.4 Social impacts

Urban pests have a number of direct and indirect impacts on the people who live near or interact with them.

Pests can pose a risk to human safety and property. Road collisions with wild and domestic animals are common everywhere. In urban Queensland, from 1995 to 1999 there were 64 reported road collisions with wild animals, of which 34 (53%) resulted in human injury or death. Wild animals were implicated in transport impacts worth $4.9m annually, 31% of the cost of vehicle accidents for all animals. Macropods undoubtedly account for much of this damage, although road accident statistics do not differentiate between species. It is not possible to accurately estimate the economic impact of non-native pest animals, although it is likely that some can be attributed to collisions with horses and deer. The cost of vehicle collisions with animals is underestimated, as statistics are not collected where there is no human injury and damage is less than $2,500 (Australian Transport Safety Bureau 2000).

Animals in and around airports are an important concern for urban pest managers. Urban airfields accommodate the bulk of national passenger and cargo traffic and, in some locations, military traffic. Airport landscapes provide suitable habitat for a variety of exotic (and native) animals, including many gregarious species. Of greatest concern to airport managers is the potential for aircraft impact with birds. Impacts with even small birds can be catastrophic, resulting in serious loss of life or costs associated with expensive repairs and costly delays.

Brisbane and Cairns airports had the greatest number of bird strikes in 1999 in Queensland (Australian Transport Safety Bureau 2000; Bailey 2000). From 1996 to 1998, there were a total of 86 bird strikes at Brisbane Airport (Pell & Jones 1999). Of the 14 species involved in plane strikes, the nankeen kestrel was involved in 25 strikes (29%). It is interesting to note that this species only made up 1.5% of the total annual bird count but was the most likely to be hit. Other species involved in strikes included *Ibis* species (9 strikes), welcome swallows (5 strikes) and flying foxes (5 strikes).

Some exotic birds were also a problem around airports, since large concentrations of a number of flocking species occur. The highest-risk non-native bird in the Brisbane study was the rock dove (table 7) with 5 strikes, while the second most common species was the common starling.

Table 7. Non-native bird strikes with aircraft at Brisbane Airport, 1996–1998

Species	% Contribution to total bird count	Total number of aircraft strikes	% Contribution of aircraft strikes
Rock dove	1.3	5	5.8
House sparrow	2.7	2	2.3
Common starling	18.5	1	1.2

Source: Pell & Jones 1999

Statistics on the economic cost of bird strike or other animal hazards to local aviation have not been compiled in Australia. In the United States, the air force ranks starlings and rock doves as among the most destructive species, accounting for 345 strikes on air force aircraft between 1985 and 1999, and incurring costs of over US$12 million (United States Air Force 1999).

Other animals may create unexpected, but significant hazards at airports. Aircraft may collide with mammals which obstruct runways or taxiways. Hares, foxes, pigs, deer and even feral cats have all been involved in collisions with aircraft at Queensland airfields (Australian Transport Safety Bureau 2000). Hares seeking warmth at night obscure navigation lights at Brisbane airport by resting on them, creating a significant safety hazard (J. Overton, 1999, pers. comm., 8 August) while an Ansett 737 was damaged when a fox was found inside one of its low hanging engines (Heywood 2001).

Attacks on people by the aggressive Australian magpie (*Gymnorhina tibicen*) represent an example of direct health risks posed by native animals. These attacks are very common, occurring annually in most population centres; 568 aggressive birds were recorded in the Brisbane–Gold coast region in 1999 (Jones et al. 1999). The number of injuries that result from these attacks can be significant; a study in Canberra found about 25% of those attacked required medical attention (Jones & Thomas 1998). One Brisbane study showed that six serious eye injuries were reported by two hospitals in one year due to magpie attacks. Attacks make magpies a major pest during the breeding season.

Both wild dogs and feral pigs have the potential to cause physical injury to members of the public. In areas where these animals are regularly seen, or where the pests are more used to humans, there is often a high level of community concern for public safety. Wild dogs that are used to a human presence may pose a serious danger to children (Raguse 200; Ryan 2000). This concern is exacerbated in the number of spectacular reports of menacing dogs in the popular news media. A large number of bites by dogs are recorded each year, although in most cases, owned domestic animals are responsible (Tan 1997).

5. Human Dimensions of Pest Problems in Built-up Areas

People are a major part of the urban pest problem. In order to manage pests in areas with large human populations it is important to deal with the people as well as the pests. This area of management is called the 'human dimension' of pest management is defined as that part of management that is concerned with the way peoples' attitudes to and behaviour concerning pests affect and are affected by the decisions made by managers (Purdy & Decker 1989). The human dimension is concerned with identifying what people think and do regarding pests, understanding why and incorporating this knowledge into the management process.

This management dimension is important as currently there is a tendency to apply biological understanding to pest-management problems without attending to social and cultural issues (Schaefer 1987; Andrew & Robottom 1995). Failure to understand the human dimension is regarded by a number of authors as a major reason why many human–animal conflicts are resolved unsatisfactorily (McMullin & Nielsen 1991; Decker & Chase 1997; Green, Askins & West 1997; Jones et al. 1998; Phillips, Boyle & Clark 1998; Kelly 1999).

Studies of the human dimension of pest management demonstrate that there are elements which fall into three categories:

- exploring human-dimension problems and monitoring attitudes and behaviour
- synthesising human dimensions with other knowledge regarding human behaviour
- applying this knowledge to management, and evaluating the outcomes.

These three issues will be explored in the following sections by discussing the importance of people in pest management, the history of our attitudes to animals, and the need for clear direction on responsibility for pest management.

5.1 Animal problems vs people problems

The managers of vertebrate-pest problems are increasingly becoming people managers or experts in dispute resolution (Decker & Enck 1996; Jones et al. 1998). However, the profession is largely ill-equipped to deal with the problem (McMullin & Nielsen 1991), as most of its workers have strong backgrounds in biological or ecological sciences but relatively little in social sciences (Decker & Chase 1997). This aspect of pest management is new and, to date, most of the investigation has been in United States and has been based on wildlife management.

In the last decade, wildlife managers in the United States have been placing a great deal of emphasis on analysing the social dimensions of human–animal conflict in an attempt to find more effective ways of dealing with problems which had been becoming increasingly difficult and frustrating (McMullin & Nielsen 1991; Jones et al. 1998). The American experience of wildlife management has things in common with Australia and the successes and failures, which are well documented, are worth examining.

It is important to recognise, however, that there are fundamental differences. In the United States, many native wildlife species are managed for commercial and/or recreational hunting as well as long-term population conservation. Wildlife includes deer, moose, various species of ducks, squirrels, wolves and bears. Very little of the United States literature relates to introduced animals. This contrasts with vertebrate pests in Queensland, which are predominantly non-native animals that are managed to reduce populations and/or impacts.

Public debate on the management of white deer (*Odocoileus virginianus*) in North America provides the basis for much of the literature on the human dimension of wildlife management (Green, Askins & West 1997; Baker & Fritsch 1997; Stout, Knuth & Curtis 1997). Increased deer density resulting from changes in habitat that favour deer, and human encroachment on deer habitat leads to public safety risks from road accidents and the spread of Lyme disease.

Deer management generally involves recreational hunting, although this causes public concern over safety and animal welfare. The major conflict for this species is between hunters and the government agencies funded by the sale of hunting licences, and the people who want to feed deer in their backyard. A number of community consultative and planning techniques have been tried to improve the deer management outcomes as the old quick-fix solution, culling, has not satisfactorily reduced the impact of the species or satisfied public concern about the deer.

It is clear that when people are unfamiliar with an animal they are unlikely to know how best to treat any problem with that animal. The Queensland Parks and Wildlife Service (QPWS) attends to native pest-animal complaints, which provide insight into how many people perceive animals. The QPWS has found that many people are unfamiliar with the ecology and behaviour of the animals they are in conflict with. Those who were satisfied that the problem was resolved when they were provided with information that allowed them to predict the behaviour of an animal were thus able to regain control of a situation through increasing familiarity with the animal, and perhaps devising their own simple solution to the problem (K. Krashnefski 2000, pers. comm., 6 August).

An example illustrating how familiarity influences reactions is the study of human conflict with the brush turkey (*Alectura lathami*) in Brisbane. The turkey is a large bird which incubates its eggs in large mounds, made by the male who scrapes together decaying vegetation from a 400 m radius (Marchant & Higgins 1993). Each year the QPWS receives a number of complaints about the mound-building activities of these birds, which live in 27 suburbs in western Brisbane (Jones & Everding 1991). Most of the complaints come from people who have recently moved to an area with pre-existing populations of the bird, or who live in areas in which the birds have recently appeared. They feel as if they are losing control over the orderliness of their garden. Few complaints come from long-time residents of areas with permanent populations of brush turkeys, due to people better understanding the value of the mounds. It appears the impact of the conflict changes with the perception of the problem (Thomas & Jones 1997).

A proportion of complaints in the brush turkey study (9%) came from people felt compelled to act because of pressure from a neighbour. This illustrates another important aspect of urban pest problems, that the pest manager must attend to interpersonal conflicts in addition to human–animal conflicts.

Person-to-person differences also come to a head on the urban fringe where farmers increasingly find themselves sharing with new settlers in rural-residential estates. The arrival of new settlers often means that old pest-management options may no longer be acceptable or available, and the agriculturalists feel frustrated at their inability to control a situation over which they had previously had free reign. Essentially, the frustration is with the neighbours or the authorities, or both; they may insist on restricting the use of firearms and chemicals, rather than focusing on the pest animal. The interpersonal conflict may be substantially greater than the impact of the pest. With conflicts such as this, a process is needed which clarifies where responsibility for the problem rests, and allows those affected to decide how to respond to the problem. A wealth of experience, discussed below, suggests that this approach can is very productive.

5.2 Attitudes to animals and animal control

The ways in which people's attitudes towards animals are formed are complex and depend on a variety of factors. One pattern is the tendency for urban residents to exhibit more empathy towards animals than do rural residents, whose relationships with animals are largely based on direct uses or impacts (Hills 1993). There is also a general tendency to devalue animals which are used as food or other uses by attributing fewer positive characteristics to them, and animals viewed as less intelligent, responsive or lovable generally attract less sympathy (Driscoll 1995).

Jones and Everding (1994) documented that the noise made by the roosting native Torresian crow (*Corvus orru*) consigns it to being believed to be an introduced pest by 25% of people surveyed in Brisbane. They considered that the crows were 'nasty' and could not be native wildlife, which is 'nice'. This attitude is also expressed in the media with quotes such as "Is there anyone else out there who has had enough of these ugly, noisy, revolting pest?" (Reid 2000). Nevertheless, only 18% of people regarded the birds are a serious problem and, contrary to QPWS views, few people (15%) supported removal of the birds. The notion of some peoples' pests being other peoples' pets (i.e. differences of perception), arose with 7% of those interviewed intentionally feeding the crows.

A society's historical regard for a species is also thought to be an important factor in determining broad community attitudes to it currently. In our own society, many persistent views about animals can be traced back to ancient times (Singer 1997). Strong sympathies are often held for animals which are familiar (Driscoll 1995), or which have been anthropomorphised regularly in popular media. In Australia, surveys of public opinion have shown that most people are more familiar with pest species such as rabbits and foxes, which appear regularly as characters in literature and media, than they are with many native animals (Morrison 1996), although the Easter bilby is gaining popularity.

One area of conflict relating to people's attitudes to pests are animal welfare concerns arising from vertebrate-pest management (Johnston & Marks 1997). Many people are concerned about the potential suffering associated with lethal control measures inflicted when the control measures are incorrectly used, and on the stresses placed on animals which are held, restrained, or transported.

Two important observations on these concerns can be drawn from overseas. Firstly, conflicts can often be avoided by involving organisations with a concern for animal welfare in planning pest-management programs (Siemer & Brown 1993; Enck & Decker 1997). Constructive interaction between the two groups may allow participants in the debate to reach agreement on what is acceptable, and may also offer an opportunity to improve community awareness about important issues in animal ecology and technical aspects of control work (Jones et al. 1998). In some cases conflict may be resolved before any protest action occurs, thereby reducing the possibility of the issue coming to the attention of the news media, which often further polarises views.

Secondly, for a variety of reasons, scepticism about the humaneness of vertebrate-pest control is likely to increase. Dismissing animal-welfare concerns will not alleviate this, but will create additional problems to the practical difficulties of discovering effective and humane pest-control measures. Consultation and education on new research on these processes would be required to prevent the loss of some control methods.

5.3 Responsibility for solving pest problems

Surveys in Australia (Johnston & Marks 1997; O'Keeffe 1999) and overseas (Reiter, Brunson & Schmidt 1999) indicate that there is confusion among the public about who should assume responsibility for solving pest-animal problems. There are several approaches for managing stakeholder involvement and current practices fall into both ends of the range from the government taking all responsibility to this resting on individual landholders (Decker & Chase 1997).

Animal-management professionals encourage community abrogation of responsibility if they adopt a top-down approach. As a consequence, there develops a commonly held view that pest animals are 'the government's pests'. The problem with this approach is that while the managers are able to act as required without much community input, this requires significant resources. An example of this is discussed by Jones et al. (1999) in relation to the QPWS south-east Queensland magpie response team (MRT). The MRT deals with the many complaints received by the QPWS from members of the public attacked by magpies. Following the establishment of the group and the generation of public awareness of its expertise, the MRT was inundated with an unusually large number of complaints from the public. Rather than demonstrating 'bad' magpie seasons this increase in complaints indicated an untapped community need for assistance and a desire from the community for the government to take over. Once groups like this become established, it is hard to disband them as community members have learned to expect others to act on their behalf and it may be hard to change this belief back to one of community responsibility.

The other end of the management continuum is the delegated approach taken in the *Rural Lands Protection Act 1985*, under which the landholder is legally responsible for pest control. The role of the State agency in this process is to provide specific expertise, managerial skills, law enforcement and training, but as part of an extensive team of stakeholders sharing a common management goal. The problem with this approach in urban areas, as demonstrated in chapter 2, is that a single pest animal could potentially affect hundreds of landowners, and a pest population thousands (figure 1). It is extremely difficult for an individual to gain cooperation from all residents, and to obtain access to all properties. In cases of this sort, there will also be agencies and interest

groups that are affected by the problem and have some interest in any action taken, and so significant coordination is required.

An alternative approach then to insisting that one landholder, organisation or agency bear sole responsibility for a pest problem is the consultative 'transactional' process that has been evolving in wildlife management agencies in the United States. Shared responsibility for animal problems is being adopted as a practical approach (McMullin & Nielsen 1991; Lund 1997) where the pest manager initiates and implements processes in which the stakeholders interact between themselves rather than through the manager. This approach retains the professional standing of the manager and greatly increases the input and influence of the stakeholders. An important lesson in these consultative processes is that stakeholder beliefs and attitudes are not static; this represents a potential for education and modification of beliefs.

A Queensland example of an effective community-managed response to an urban pest issue was a wild-dog baiting campaign coordinated in the Mackay region by the then Department of Natural Resources in 2000. Increased wild-dog activity on the urban fringe led to a public meeting. Landholders at this meeting organised themselves into strategic working groups based on the identified problem areas. Each area supported unique geography and landforms, and best-practice management determined for each site. Within The best practice identified at numerous sites was as the use of 1080 chemical control, and in 17 areas community members undertook control using aerial baiting; the group in another area employed a shooter. The program resulted in increased knowledge about and ownership of wild-dog management in the area as well as a decrease in the impact of wild dogs.

6. Control Methods

Vertebrate pest management has often been ad hoc and reactive, particularly so in built-up areas. The delivery of vertebrate-pest management in built-up areas has been at times ineffective (Braysher 1993; Jones et al. 1998) as the techniques for controlling pests are often selected before the pest-management objectives are thought through. In many past management programs the implicit objective has been to eliminate as many pest animals as possible, and so the method known or thought to be the most effective at killing animals was preferred. If there was a choice between methods, it was common for pest managers to choose the method that was the most familiar or least costly in the short term. For many pest-control methods, however, action taken over larger areas over a longer time are more effective than killing the pest; in fact, killing may not be required. It is important that the full range of control options available for each pest is reviewed for each situation, although in some cases the options currently available do not result in control.

6.1 Options for pest control

There may be additional technical constraints on the methods used for pest control in built-up areas than those that normally apply in rural areas. These are in relation to concerns over the health, safety and environmental risks of the method (Johnston & Marks 1997), or resulting in or being a consequence of legislative or operational controls on the use of some techniques. These concerns may exclude the use of some methods in built-up areas, severely limit others and place additional restrictions on many. At the same time pest management can be limited by an inadequate understanding of the ecology of the species in the built-up area, a lack of resources, and constraints resulting from increased community involvement.

There are five groups of useful approaches for the control of pest animal damage in all situations (Olsen 1998):

- killing or removal by poisoning, shooting, trapping or mustering
- exclusion
- biological control
- habitat manipulation
- practices such as changes in land use or management.

Carroll and McGaw (1997) have reviewed some of the commonly used and novel methods of vertebrate-pest control. Several new or additional methods of pest control show promise. Although they are not likely to have universal application, the benefits they provide over traditional methods are that they are effective in particular circumstances, able to be used with flexibility, or able to employ community members for at least some of the labour component. There are a large range of methods that can be used to reduce pest impacts; however, they may not all be as affective or applicable in all cases. The control methods currently in use, their advantages and disadvantages, and the regulations for their use are listed in Appendix 1.

Surveys of public attitudes to pest-control methods suggest that the public prefer the use of non-lethal control methods (Jones & Everding 1994; Jones & Thomas 1998; Phillips, Boyle & Clark 1998; Reiter, Brunson & Schmidt 1999). This may be because these methods are seen as more humane

(Messmer, George & Cornicelli 1997; Messmer et al. 1997) or because the public is unwilling to accept any risk of death of animals that are not being targeted (Johnston & Marks 1997). Although the public support the use of non-lethal control methods, in practice most of these are labour intensive and therefore expensive. Improved information to the public on pests and pest-control methods may help pest managers to identify preferred or publicly acceptable control options when there are several alternatives.

A recent study of the public acceptance of magpie control in Brisbane gives an example of community feedback (Jones & Thomas 1998). People in three groups, those directly affected by magpies, members of wildlife groups, and a randomly selected group of the public, were asked questions about their support for current management measures. The highest acceptance was for the use of signage and building of public awareness (79%–95%), although people in both the wildlife and randomly selected groups also strongly supported (> 70%) no action. Very few people, including only 30% of those directly affected by magpies, supported the humane killing of magpies, even though this is the main method of control in other parts of Australia. The affected group did not support doing nothing (only 15% responded positively to this idea); instead they supported the relocation of birds, and the use of this method is now being evaluated by the Environment Protection Agency.

Education can be classed as a control method because of its importance in ensuring that important control programs are properly planned and run smoothly. There is evidence that the public has some appreciation of the importance of vertebrate-pest management, and is likely to support the activities of pest-management professionals when they have a good understanding of the principles of animal ecology and wildlife management (Green, Askins & West 1997). Successful pest management projects in Queensland's urban areas have been run in an open manner that stressed community awareness and encouraged public inquiry. For example, work in Noosa National Park that used a community consultation and involvement program led to reduced predation by foxes on a variety of vulnerable fauna and has resulted in increased numbers of swamp wallaby ('Roo numbers rise as foxes chopped 2000).

6.2 Animal welfare issues

In Queensland the *Animals Protection Act 1925* gives no protection to feral animals from being controlled but it does provide, in broad terms, that procedures to destroy declared animals must not constitute 'unreasonable, unnecessary or unjustifiable ill-treatment'. Ignorance of legislation is not an excuse for handling an animal inappropriately. The intent of the Act is to reduce animal suffering and stress as far as practicable. This legislation is being reviewed, and codes of practice for the welfare of animals are being coordinated nationally. In the interim, with codes of practice that only cover 'feral livestock' and some forms of control of these species, it is up to the individual involved in pest control to be responsible for ensuring the actions taken are consistent with the legislation.

What constitutes unnecessary suffering is open to interpretation, and may involve a degree of subjective evaluation that is ultimately decided by the courts. Furthermore, the limits of what the community accepts as humane change with shifts in social values. Community pressure can be a significant trigger for action and so problems in meeting statutory requirements or abiding by established

codes of practice may arise because there are no universally agreed methods by which we may judge the degree of animal suffering (Barnett & Jongman 1996; Marks, Hackman & Gigliotti 2000).

The priorities of organisations concerned with animal welfare differ: animal welfare organisations such as the RSPCA focus on individual animals; the energies of conservation organisations are directed at species, populations or ecosystems. In general, animal-welfare advocates recognise the seriousness of production and environmental impacts created by exotic pests (Royal Society for the Prevention of Cruelty to Animals 1998) and generally, support the development of animal control programs that seek to reduce impact rather than animal numbers, per se (Oogjes 1996). Focusing on impact reduction implies taking a broader, ecosystem view of pest management (Marks 1996). Concern for the welfare of individuals animals need not be abandoned, but would be considered within the context of more general good to the community. An important part of this process would be to examine the consequences of not acting to control a pest (Marks 1996).

Some control methods only result in the capture of the animal. In the case of declared animals, although this action removes it from the community, it still needs to be destroyed. Therefore, other options, for example relocation, are not available. It is important that the community is made aware of this.

7. Legislative Status and Policy

7.1 Commonwealth

The eradication or effective control of new pests is best carried out as soon as possible following detection of the animals or impacts (Braysher 1993). Obtaining support for this action may be difficult if the animal is poorly known or the impact it has is not immediately obvious. This is why the import, keeping, trade in, and movement of animals is regulated through federal and State legislation. Nationally, the Australian Quarantine and Inspection Service administers the *Quarantine Act 1908* and Environment Australia the *Wildlife Protection (Regulation of Exports and Imports) Act 1982*. Once an animal is established in Australia, trade in, and the movement and keeping of the animal is subject to State and Territory legislation.

Risk assessment using criteria developed by Bomford (1991) are used by the Vertebrate Pests Committee (VPC) to assess the status of animals as potential pests. The VPC also recommends methods and procedures for the containment and transport of animals that have been imported. This committee is made up of representatives of vertebrate-control agencies from each State and Territory and the Commonwealth.

Trade in exotic animals is controlled by two international agreements; the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which is concerned with the movement of rare and endangered animals, and the Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS Agreement), which deals with the application of food safety and animal and plant health regulations to the international trade in animals, plants and their products. Action taken in Australia by federal government departments are supposed to be consistent with the direction of these agreements.

The Commonwealth Government addresses the issue of environmental harm from established pests under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC), which replaces the Act that previously governed environmental harm, the *Endangered Species Protection Act 1992.* This Act gives the Commonwealth general powers to support the principles of sustainable development and the conservation of biodiversity, and to mitigate or prevent environmental damage, and more specific powers that support the conservation of ecological communities and threatened species.

Commonwealth agencies are required to implement and enforce the EPBC and this legislation allows the Commonwealth to enter into bilateral or cooperative arrangements with the States or private landholders to:

- promote the objectives of the Act, including those concerned with pest (feral) animal management
- facilitate coordination of a unified approach to reducing the impact of threatening processes.

Commonwealth policy is aimed at encouraging cooperative arrangements and coordinated action in relation to species listed as contributing to threatening processes. Four species are described as causing serious environmental harm under this Act: the European red fox, the feral cat, the feral rabbit and the feral goat. Each is exotic, threatens wildlife through predation or competition with

native fauna, and contributes to land degradation. As part of threatening processes, each species must be the object of a threat-abatement plan, the purpose of which is to reduce, to an acceptable level, the impacts of processes that threaten the long-term survival of native species and ecological communities (Biodiversity Group 1999a, 1999b, 1999c).

Other pieces of Commonwealth legislation that may be relevant are the *Agricultural and Veterinary Chemicals Act 1994* and the *Biological Control Act 1984*.

7.2 Queensland

The control of pest animals in Queensland is regulated under the *Rural Lands Protection Act 1985* (RLPA), which compels landowners or land occupiers to control declared pest animals on their land. The Act specifies eight categories which indicate the level of control required for particular species; these are shown in table 8. It should be noted that animals may be declared in more than one category. For landowners, three categories have most significance in directing management of existing vertebrate pests on lands. These are A2, A5 and A7.

Feral cats are listed as contributing to threatening processes under Commonwealth legislation but are not listed in Queensland. Non-indigenous mammal species not specifically cited in the Act are declared in categories A1, A2 and A3. Exotic birds, fish and invertebrates are not currently declared under the Act. Only one native mammal, the dingo, is declared in any category. All other native species are specifically protected under the *Nature Conservation Act 1992*, as are dingoes inside national parks. Native animals which are pests can only by taken (kept, shot, killed, hunted, wounded, poisoned, baited) with a licence or authority under a regulation of the *Nature Conservation Act 1992* (division 4, s. 88 (1)).

Table 8. Pest animal declaration categories in Queensland

Declaration category	Management requirement
A1	Introduction of these animals is prohibited
A2	Exotic animals that must be destroyed
A3	Keeping and selling is prohibited
A4	Introduction subject to prescribed conditions and restrictions
A5	Numbers to be reduced and kept under restriction
A6	Keeping and selling subject to prescribed conditions and restrictions
A7	Native animals that require a management program
A8	Plague species (locusts only)

The Department of Natural Resources and Mines is responsible for ensuring implementation of the RLPA on State, municipal and private lands. The department requires that local governments enforce the control of pest animals by landholders. The Act empowers local governments to issue notices requiring pest control to be carried out within a specific period. If the landholder fails to carry out control work, the council may authorise persons to enter the property or properties to carry out the work, and may then take action to recover the costs. The department does not provide a general pest-control service to the

community or landholders. Unfortunately, there are few vertebrate-pest controllers who have the skills to operate effectively in the built-up environment, although there is growing interest in filling this niche.

The Department of Natural Resources and Mines does provide some advice to landholders, and some assistance in responding to acute pest problems. In built-up areas, most of this type of work is reactive, and there have been few attempts to implement pest control at scales that reduce the impact of pests. In rural areas the department provides a 1080 bait preparation service and assists to coordinate cooperative pest-management programs involving multiple stakeholders. A similar service is not routinely provided in built-up areas. However, there have been some important successes in the limited number of cases where the DNRM has been directly involved in relatively extensive control programs in built-up areas. The department also conducts research on pest-animal biology and ecology, and on various aspects of control. These can be applied equally in built-up and rural environments.

Other pieces of legislation which may be important in the management of pests in built-up areas are the *Animals Protection Act 1925, Weapons Act 1990, Stock Act 1915***,** *Dividing Fences Act 1953*, *Exotic Diseases In Animals Act 1981*, Health (Drugs and Poisons) Regulations 1996, *Health Act 1937* and local laws under the *Local Government Act 1993.* It is important to note that noise, such as barking dogs, is also regulated by the *Environmental Protection Act 1994*, the Environmental Protection (Noise) Policy 1997 and local government laws.

8. Conclusions

The role of this report is to collate the current state of knowledge on vertebrate pests in built-up areas as it was recognised that they represent a special set of problems in the management of pest animals. With population increases in urban areas across Queensland and the growing fragmentation of the environment these problems are bound to increase in the future. Although this report has documented a number of deficiencies in the current practices and knowledge it is important to note that successful pest management in built-up areas has occurred and continues to occur across Queensland.

It is clear that pest animal problems will increase and continue to be both controversial and time-consuming in the built-up areas of Queensland. This trend will persist with increasing numbers of people living in urban areas in Queensland and the density of pest animals due to increased food sources, a decrease in available habitat, or both.

There are five key issues restricting effective management of pests in built-up areas: poor knowledge of the pests; lack of community awareness about pest issues; the importance of the human dimension being underestimated; lack of effective control options; and inappropriate response and coordination.

The knowledge base on which vertebrate pest management is planned in built-up areas is often incomplete or inadequate. Information on the ecology, behaviour and impact of many pest animals in built-up areas is deficient. For example, only in recent studies on the removal of aggressive male magpies has it become clear that females acquire a new mate soon after the original mate is removed which may result in increased aggressiveness from the female (Jones et al. 1999). Specific studies and the cataloguing of social, production and environmental impact is required to enable the public and pest managers to make decisions based on facts rather than inferences. One pressing example is the health risk posed by some pest animal species, this requires a clearer understanding of both the risk and methods to reduce this risk to the community.

Information on pest management and pest animals is not easily found by many people living in built-up areas, including pest managers. Unfortunately to date opportunities to collect and disseminate information from existing pest-management programs have been missed. Much experience exists only in the ‘grey literature’ (people’s minds) and may not be transmitted to others. As well, many pest managers operate in isolation. Inevitably this results in some workers having to reinvent the wheel with each new activity. To ensure this information reaches the audience; fact sheets or workshops are needed to ensure two-way information sharing between managers. Another pressing need is for accurate density and occurrence mapping of pest species. This mapping needs to be at a scale which allows pest management within the urban context and in enough detail that management plans and strategies can be developed.

A number of vertebrate pests were pets which have reverted to a wild state. Because of the huge environmental and economic costs of this, it is important that new pet species are assessed for their potential to become pests. If they fail this assessment it would be best that their introduction is prevented. To minimise the impact of established pet species, it is important that domestic pets are better managed so that they do not exacerbate their current impact on fauna or begin to pose a risk to human health. This is one area where the public

can–indeed must–play a central role. There is also an increasing risk from native animals to become significant pests if their environment is dramatically altered (for example the roosts of flying foxes being destroyed) or if new diseases enter Australia for which endemic species become carriers. Again knowledge on the impacts and ecology of these species may be sparse.

Many conflicts with pest animals have their roots more in human perceptions and behaviour than in animal behaviour or ecology e.g. dogs on the urban fringe, crows in cities. An understanding of public sentiment in respect of human-animal conflict has proven necessary for effective long-term wildlife management in the United States (McMullin & Nielsen 1991; Jones et al. 1998). A similar requirement is indicated for pest management in urban Queensland.

Good information flow may provide the basis for effectively encouraging the public to take a greater share of responsibility for pest problems in the urban areas. However, this is not to argue that public sentiment should drive pest management. Rather public surveys and other methods of finding out public views should be used to allow pest managers to make efficient use of resources and community knowledge, and to carry out their mandate effectively. Excluding citizens from decision making entrenches dependency on government agencies. If the public perceives that its only practical role in managing their pest problems is to complain, then this may be all they do. Therefore, there is a need to involve communities in solving their own problems and so a top-down approach on behalf of agencies will be counterproductive, they should instead play an advisory role in consultative processes, along with local government. There is compelling evidence that, concerning conflict over the management of animals, wildlife managers frequently misjudge public opinion and expectations (Jones et al. 1998; Phillips, Boyle & Clark 1998). Pest managers who do not communicate with the public may fail to understand the social obstacles to carrying out their work but at the same time they may also fail to recognise community goodwill and potential sources of support that this may represent.

The range of pest control options in the built-up areas is currently very limited. The most clinically effective methods may have associated unacceptable health, safety or environmental risks, or be unacceptable by the public for some other reason. Even when all affected parties are willing to resolve pest-animal problems in the built-up areas, in many situations there are no acceptable control methods. As demonstrated in appendix 1 a large number of control options may be possible but they may require planning or considerable resources. Ways must be found to modify and integrate existing methods and to investigate novel control methods. The development of the latter should be documented to assist others implement and improve on them.

It is important that all staff are trained in the most acceptable and effective control techniques. At present there is a lack of expertise in vertebrate-pest management at the local government level. This is one issue that prevents local authorities from taking on the responsibilities for planning and carrying out effective management of vertebrate pests. In most local government divisions that deal with animal problems there is relatively little experience or training in vertebrate-pest management. It can be expected that local governments would look to State agencies with expertise to provide the support and training to allow them to meet their responsibilities. National training standards for vertebrate pest control, currently in the draft stages of development, will assist with the delivery of this skills base and acceptance of this responsibility by councils.

A lack of documented and broadly accepted codes of practice for animal control including animal welfare issues causes concern for pest managers. This may be reason for the lack of action on some urban pest problems. This deficiency needs to be clarified at a national level.

One feature of pest management in built-up areas is the large number of land owners and land managers affected as shown in figure 1. Thus, in densely settled areas, it may be difficult for individual landowners to meet their legal obligations to control declared animals, or at least there may be a perception that this is so. This will undoubtedly be a continuing source of requests for the State to assist landholders to carry out pest control and this will require adoption of control methods and policies that are tailored to built-up areas.

No single agency or organisation is charged with the responsibility for managing all pest animal problems in built-up areas. Each agency has its own interests in and responsibilities for the various pest animals, and these may differ. Where these responsibilities for pest animals are set by administrative or property boundaries, cooperation between all responsible agencies, as well as other organisations and landholders is required to undertake meaningful pest-management work. Members of the public are often unsure where to seek advice or information about pest management. Telephone enquiries are often redirected to the wrong person or place, which frustrates callers and reinforces the notion that pest management is poorly organised. Initiatives such as Access Queensland, which is a whole of government initiative to streamline community queries should assist. At the same time it is important that pest management is coordinated and access to information and expertise about it communicated clearly to the community as well between the agencies involved.

As public interest in and awareness of resource management issues increases, the demand for government action to control pest animals has increased (Fall & Jackson 1998; Department of Natural Resources 1999). Since a decreasing proportion of the population is directly involved in primary production, concern over pest animals is encompassing all pest animals of significance; those which are declared under the *Rural Lands Protection Act 1985* and those undeclared pests that may generate environmental, public health or nuisance impacts. Community concern over the impact of pest animals is already reflected in appeals to control certain undeclared species and to see additional species or taxa declared. Frequently, these requests are for control of species thought to have a negative environmental impact. There is currently no statutory requirement for any landholder to control undeclared exotic animal pests. These gaps, confusion over the role and reasons for legislation other possible legislative inadequacies or conflicts need to be resolved.

In the future there is likely to be a continued and increasing public demand for significant government assistance in ensuring that land owners are able to meet their legal obligations to control declared pest species. Given that the majority of the population lives in large population centres, and the fact that a number of declared species are common in these areas, it is reasonable to expect that an increasingly significant proportion of requests for pest management assistance from the State will come from the urban public. This may require a realignment in resources both financial and personnel in government agencies.

Successful vertebrate pest programs in built-up areas have a number of common features. The list below documents these features and could act as a checklist for managers faced with planning projects to address similar problems.

- ☐ Include basic information collection in the project to allow for the precise definition and quantification of the problem
- ☐ Undertake planning prior to acting
- ☐ Ensure the people involved are trained or experienced
- ☐ Avoid adopting a pest-management technique before the problem has been analysed
- ☐ Maximise close cooperation between all stakeholders
- ☐ Involve significant participation by the affected community, including 'critics' as well as 'supporters'
- ☐ Make sure the program is achievable - do not adopt unattainable goals as adopted (e.g. reducing fox impact as opposed to eradicating foxes)
- ☐ Base the program on an adaptive approach to problem solving
- ☐ Incorporate monitoring, making an additional use of control work which provides an opportunity to collect information for review and for planning future action
- ☐ Present positive objectives (e.g. saving wildlife') and not just negative outcomes (e.g. killing so many dogs)
- ☐ Recognise that the 'job is not done' until the participants are satisfied that the work has been completed
- ☐ Ensure that initiative, flexibility and lateral thinking are important and are incorporated into planning or implementation
- ☐ Getting on with the job in a quiet and orderly manner without informing people of activities may be one timely and effective option
- ☐ Review the program upon completion
- ☐ Sustain the project over the area and for the time needed

9. Appendix 1. A summary of the vertebrate pest control methods

Table A. Pest-control methods that involve killing or removal that exist or are under development

Control method	Target	Legislative control	Advantages of use	Disadvantages
Bait-impregnation poisons				
Fluoroacetic acid (1080)	Wild dog Fox Pig Rabbit	Schedule 7 poison Qualified and authorised DNRM or local government officer only may carry out bait impregnation service Guidelines for use specify baits should not be laid within 2 km of residence, or 5 km of a 'town'; no baiting on less than 5 ha; 72 hours notification of baiting required; warning signs must be placed	Highly effective for some difficult to control species (e.g. foxes) Degrades rapidly Landholders may purchase commercially prepared baits Bait, concentration and method of presentation can be varied depending on the target species	Risk of non-target impacts if not used properly Human poisoning risk (no effective antidote) Extensive community consultation may be required Requires changes in landholder practices during baiting campaign (e.g. dogs kept on leash)
Strychnine	Wild dog Fox	Permit to purchase and use must be obtained from Queensland Health Prohibitions on resale	Sometimes used in conjunction with leg-hold traps to reduce animal welfare concerns Rapid action	Non-target effects: not as selective as 1080 Concerns exist about humaneness of use of the poison No antidote
Pindone	Rabbit	Schedule 6 poison	Highly toxic to livestock, and moderately toxic to other animals, including dogs and cats Possible non-target effects Correct application requires 3 feeds; requires multiple exposure	Registered for use on rabbits Antidote available
Fumigant poisons				
Chloropicrin and Phosphine	Rabbit (warren fumigant)	Schedule 7 poisons	Can be humane Little off-site risk Target specificity	Lethal in low concentrations Risk of non-target poisoning

Table A cont.

Control method	Target	Legislative control	Advantages of use	Disadvantages
Carbon monoxide	Fox (warrens) Birds (eg. Myna roosts)		Could be safely used where risk from baits is high Low environmental impact Humane	Limited circumstances for use Possible non-target impacts (e.g. wildlife using old dens) Labour-intensive
Other poisoning methods				
Mechanical ejector (under development: not currently registered)	Wild dog Fox	Apparatus is category R firearm under Weapons Act Chemical (cyanide) not currently registered	Delivery system is relatively selective	Experimental Can only be used by suitably trained and equipped person High level of training required Low public acceptability Potential safety risk for authorised workers and public Labour-intensive
Mechanical capture				
Box (cage) trap	Wild dog Cat Pig Fox		High level of public acceptability Reusable Commercially available	Time and expense in holding and dispatching captured animals Labour-intensive Suitable designs not available for all animals Success requires skill Non-target impact risk
Nets, various types	Mammals Birds	Some delivery systems regarded as firearms under Weapons Act	Flexible use Can be used on animals that are otherwise difficult to control (e.g. some birds, deer) High level of public acceptability	Labour-intensive High level of training required Limited circumstances for use Need to kill animal after capture Risk of injury to/from animals In most cases, cannot be used for sustained control

Control method	Target	Legislative control	Advantages of use	Disadvantages
Snares	Wild dog Fox Pig Other mammals with adaptation	Some interpretations of the Animals Protection Act might preclude use of snares due to harm that may be caused	Inexpensive Flexible locking types reduce animal injury Flexibility in placement	Potential for non-target impacts Moderate training requirement Very low public acceptability Some types require animal dispatch following capture Labour-intensive
Leg-hold (soft-catch) trap	Wild dog Rabbit Cat Fox		Low risk of physical injury to animals Highly effective when used correctly Can be successfully combined with attractants Flexibility in placement	Public may not distinguish from steel-jawed trap Animal welfare concerns (monitoring of traps, animal stress and injury) Labour-intensive High level of training required Target specificity Animal needs to be destroyed
Steel leg-hold trap	Wild dog Fox Cats		Highly effective when used correctly Can be successfully combined attractants Flexibility in placement	Low public acceptability Animal welfare concerns (monitoring of traps, animal stress) High risk of injury to animals Labour- and skill-intensive Animal needs to be destroyed
Other removal options				
Firearms	Most animals	Weapons Act regulates availability, ownership and use of firearms Federal code of practice establishes guidelines for firearm control of feral animals Many local governments have restrictions on use in local laws	Quick response to problem animals Can be used for control of many kinds of animals Potential uses in rural residential areas High target specificity	Unsafe if used by unskilled operator Unsuitable under most circumstances in densely populated areas Substantial confusion over legalities of use

Table A cont.

Control method	Target	Legislative control	Advantages of use	Disadvantages
Immobilisation drugs	Large mammals	Weapons Act and Weapons Regulation 1996 regulate availability, ownership and use of delivery devices, including blow pipes and crossbows Local government areas may have local laws restricting use Substances used for immobilising are regulated	Can reduce risk of human injury in handling High public acceptability May be used on animals for which there are limited control options Many delivery systems available	Not readily available Restrictions on use increasing High level of training required Labour-intensive Concern over misuse of anaesthetics Expensive on large scale Animal needs to be destroyed
Dogging (chasing and/or holding animals with dogs)	Pig	Potential but unclear conflicts with Animals Protection Act	Possibly useful in rural fringe areas Target specific	Unsuitable under most circumstances in densely populated areas Public acceptability varies, especially concerning safety Potential non-target impact Concerns over animal welfare Skill required
Mustering	Horse Goat		Effective in dense populations in open areas Target-specific Captured animals can be sold	Difficult in the mosaic of land uses typical of urban fringe Skilled operators required Expensive Animal needs to be destroyed

Table B. Pest-control methods that involving exclusion that exist or are under development

Control method	Target	Legislative control	Advantages of use	Disadvantages
Fences	Ground-dwelling animals	Local laws prescribing fence construction (may vary with local government area) Australian Standard may apply for electric fences	Potential for protection of high-value livestock or crops Potentially useful on rural fringe May be the only effective solution to problems for some animals (e.g. foxes) Fence problems in as well as out	Very expensive High maintenance May only shift problem from one place to another May cause impacts on native fauna
Nets	Birds		Effective Acceptable to public Cost-effective for high-return crops	Expensive Subject to damage requiring maintenance and replacement Animal welfare considerations
Tree guards	Hare Rabbit		Range of materials can be used High public acceptability Reusable May create microclimate that assists in plant growth	Skills required for effective guards May be expensive Risk of damage to animals if not correctly secured
Repellents	Hare Rabbit Deer Flying fox		Costs of some are low Can be homemade Easy to handle	Not widely used Effectiveness is seasonal or short-lived Success can not be guaranteed
Electronic devices (light and sound)	All pests		High public acceptability Non-lethal Low level of skill required	Can disturb neighbours Animals learn to tolerate Variable success Shifts problem

Table C. Pest-control methods that involve biological control that exist or are under development

Control method	Target	Legislative control	Advantages of use	Disadvantages
Biological control agents (e.g. myxoma virus, rabbit calicivirus)	Rabbit	National Registration Authority registered	High public acceptability Potential to reduce pest impact Low non-target and health risks if properly applied Flexible Can be integrated	May require inoculum for pets and domestic stock Expensive and slow to develop Only available for limited number of species
Immuno-contraception (currently under development)	Mouse Rabbit Fox	Use of recombinant material regulated by Biological Control Act	Potential to significantly reduce pest impact Flexible Long-term solution Low cost and skill in distribution	Not yet available Expensive to develop Requires inoculum for pets and domestic stock Problem with public acceptability of genetically manipulated organisms

Table D. Pest-control methods that involve habitat modification that exist or are under development

Control method	Target	Legislative control	Advantages of use	Disadvantages
Habitat modification (e.g. destroy dens, remove food and water sources, pro vide owl boxes)	Variety of animals, depending upon life history	Various Acts and local laws, depending upon situation and type of modification	Limit resource availability (e.g. breeding sites) High acceptance May be particularly useful in combination with other measures Increase in desired predators (e.g. owls) Passive method to reduce pests	Potential poorly realised for most species Can shift problem from one place to another May be ongoing activity Conflict with vegetation-management legislation

Table E. Pest-control methods that involve altering management practices that exist or are under development

Control method	Target	Legislative control	Advantages of use	Disadvantages
Guard animals (e.g. dogs, llamas)	Wild dog Fox		High public acceptance May be very useful on urban fringe Applicable for high-value stock Potential for additional income	High level of training required Useful only to protect livestock Safety risk from improperly handling Local laws may prohibit use Difficulty obtaining suitable animals High cost
Penning or shedding stock	Wild dog Fox		Used for large commercial holdings or where few livestock are kept	
Enterprise substitution (e.g. switching to another animal or crop or change land use)	All		Problem no longer applies	New enterprises may cause other pest problems
Education	All		Attains large-scale action Informal decision making May be expensive in the short term to develop new programs	Requires a large proportion and number of the population to be involved Education does not 'kill things' Cost-effective in long term as prevention actions as cheaper than direct action

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