DEER

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Family cervidae

in Queensland

PEST STATUS REVIEW SERIES – LAND PROTECTION

by
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Queensland Government
Natural Resources and Mines

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1. Summary

Eighteen deer species were introduced into Australia in the late nineteenth and early twentieth centuries, mainly by acclimatisation societies. The majority of these animals perished. However, six of the liberated species survived and went on to form viable wild populations. The six species—all belonging to the subfamily Cervinae—are chital deer (*Axis axis*), hog deer (*Axis porcinus*), red deer (*Cervus elaphus*), rusa deer (*Cervus timorensis*), sambar deer (*Cervus unicolor*), and fallow deer (*Dama dama*).

Four of the species are found in established populations in Queensland:

- chital deer around Charters Towers in northern Queensland
- red deer in the Brisbane and Mary River valleys of south-east Queensland
- rusa deer on islands in Torres Strait
- fallow deer in southern Queensland around Stanthorpe and Warwick.

Deer were hunted for food and sport in the years following the establishment of these populations. However, the legal position changed when deer were declared protected species under the *Fauna Conservation Act 1952*. The new Act accorded deer a status similar to native animals and effectively outlawed recreational deer hunting. However, despite the law, hunting continued illegally because of the strong hunting community in the state.

The situation continued until the emergence of deer farming in the 1970s. Wild deer were still protected, but a permit system was introduced to enable deer trapping. Once captured, deer were accorded a new status similar to domestic animals. In time, both the practice of deer farming and the locations in which farming was permitted were controlled by the *Deer Farming Act 1985*.

This exploitation of wild deer herds to obtain farm stock also led to stronger calls for legal hunting access. In response, beginning in 1976, hunting seasons were introduced. However, the change had little impact on recreational deer hunting. For those who were already part of the deer hunting community, illegal hunting continued much as it always had, while newcomers had little chance of obtaining legal access.

In the 1990s, the entire system of deer management was turned on its head. First, the *Nature Conservation Act 1992* removed the protected status of the species. This was followed by the repeal of the Deer Farming Act, which removed restrictions on farming. For a short time, deer were accorded pest status under the *Rural Lands Protection Act 1985*, but they were subsequently removed from the list of declared animals by the Rural Lands Protection Amendment Regulation (No. 1) 1997. The end result of these changes was that there was no longer any Queensland legislation for the management

and control of wild deer and that those on farms were subject only to regulations applying to domestic stock generally.

At the same time, around the mid 1990s, the deer farming industry suffered economic setbacks. This, combined with several years of drought, saw the value of deer plummet. With no controls remaining, many deer were released by farmers or purchased at low prices by individuals seeking to establish their own herds for hunting or aesthetic purposes. It is estimated that more than twenty new deer populations were established in Queensland during this time. A similar trend in the establishment of new deer populations and growing numbers of wild deer occurred in other states.

Regulations established under the *Land Protection (Pest and Stock Route Management) Act 2002* continue to exclude from the list of declared animals eight species of deer, which may be found in zoos or farmed in Australia.

While deer have a certain value as farmed stock or game animals, the recent rapid increase in numbers and uncontrolled populations emphasises the potential pest problem that deer represent. As deer become more widespread and visible, there are reports of them causing agricultural and environmental damage, and concerns about their potential to carry stock and wildlife diseases. Wild deer are also creating social impacts as they encroach on outer urban areas, causing damage in parks and gardens, and increasingly becoming involved in vehicle accidents.

The supporters of deer argue that, although an introduced species, they are now a part of the Australian environment and their control should be an integral part of wildlife management. But the same argument is not made for other introduced animals—foxes, cats and rabbits, for example—and needs to be balanced against the threat that deer pose to the environment. In particular, claims that tropical deer species (sambar and hog deer) have been released in Queensland raise significant concerns.

An argument can be made for managing wild deer in Queensland as game, provided that economic, environmental and social risks can be minimised. The argument is not incompatible with declaring the four species of deer historically established in Queensland as class 2 pests, but applying the declaration only to deer outside the historically established range of each species. A case can also be made on environmental grounds for declaring all other deer species not yet established in the state as class 1 pests. These measures would set up a structure under which the potentially adverse impacts of deer could be managed, while acknowledging that deer have a historic presence in Queensland and are highly valued by some groups in the community.

Recreational deer hunters and other groups within the historic deer ranges are likely to support this approach if wild deer can be managed as game within those areas. At the same time, environmental groups, including hunting organisations with an active interest in conservation, are likely to lend their support to the eradication of new deer populations outside the historic deer ranges.

Finally, to manage wild or feral deer as potential pests, it is essential that the issues of farmed deer be addressed. This requires a definition of farmed deer, which distinguishes the animals from wild deer and a regime for the management of farmed deer, which precludes them from passing back into the wild.

2. Taxonomic status

Deer are ungulates (hoofed mammals) belonging to the order Artiodactyla. Recent fossil and molecular evidence has broadened the coverage of the term 'ungulate', but those mammals referred to as the true ungulates are divided into two orders:

- the Perissodactyla (odd-toed mammals including horses, donkeys, zebras, rhinoceros, tapirs and camelids)

- the Artiodactyla (even-toed or cloven hoofed mammals ranging from domestic cattle, sheep, goats, pigs and their wild rootstock, to antelope, camels, giraffe, and deer).

As this grouping indicates, deer are biologically close to major domestic animals and, as a consequence, carry many of the same parasites and are susceptible to the same diseases. This is an important consideration in addressing issues in the management of deer.

Within the order Artiodactyla, almost all deer species are placed within the family Cervidae. The two exceptions are the musk deer, (family Moschinae) and mouse deer or chevrotains (family Tragulidae) which both differ significantly from Cervidae.

There are currently about 44 recognised species of deer within 17 genera in the family Cervidae worldwide (Fox & Myers 2001). These are divided into two broad groups: the old world group covered by the subfamilies Cervinae and Muntiacinae, and the new world group in the subfamilies Hydropotinae and Capreolinae (sometimes referred to as the Odocoilinae). The subfamily groupings are pointers to the areas in which the species evolved rather than their later geographic distributions. It is thought that the new world deer evolved about 5 million years ago in the forests of Siberia and North America while the old world deer evolved in southern Asia.

Over the millennia, deer have spread through natural dispersion to occupy suitable habitats in Europe, Asia, the Americas and northern Africa. In historic times, human intervention has also resulted in deer being introduced into Australia, New Zealand, New Guinea and a number of the islands of Oceania. This gives the deer family an almost global distribution (De Vos 1982; Fox & Myers 2001).

The ability of many deer species to acclimatise and colonise new ecological niches is an indicator of their adaptability. Underlying this is a wide range of intraspecific variation at the genetic level and a propensity for hybridisation, which has made the taxonomic classification of some species uncertain. This applies particularly to different populations of the genus Cervus in which many of the phenotypic (visible) differences observed between populations are thought to result from human intervention rather than genetic differences (Tuckwell 1998).

Eighteen deer species were introduced into Australia in the nineteenth and early twentieth centuries, mainly by acclimatisation societies. The majority of these animals perished. However, six of the liberated species survived and went on to form viable wild populations (Wilson *et al* 1992; Moriarty 2004). The six species—all belonging to the subfamily Cervinae—are chital deer (*Axis axis*), hog deer (*Axis porcinus*), red deer (*Cervus elaphus*), rusa deer (*Cervus timorensis*), sambar deer (*Cervus unicolor*), and fallow deer (*Dama dama*).

2.1 Description

Deer share many of the physical attributes displayed by ungulates generally. The common ancestors of the deer species acquired features that were adapted for life on open grasslands or savannahs. These were, most notably, long legs to increase running speed and specialised digestive tracts to process large quantities of grass or browse.

To lengthen the legs, ungulates evolved with digitigrade locomotion—that is, they walk on their toes, with the hoof being an enlarged toe or toes. Artiodactyls (such as deer, sheep, antelope and pigs) walk on two toes. Perissodactyls walk either on three toes (rhinoceros, tapirs, and some extinct horses) or on one toe (living horses and donkeys). The remaining toes not used for walking are either reduced or completely lost. Members of the deer family are four toed, with the two middle toes making up the cloven hoof and bearing the weight of the animal.

Within the Artiodactyla, deer are grouped with the ruminants. Most members of this group (such as cattle, sheep, goats, and antelope) possess a four-chambered stomach in which feed undergoes an initial fermentation stage in the foregut or rumen. Camels and chevrotains, which are also classified as ruminants, have a three-chambered

stomach. Ruminants 'chew the cud' to re-process food, which has undergone initial fermentation.

Many ruminants are known for the spectacular growths that adorn their heads, and which are identified either as horns or antlers. Horns are composed of a protein called keratin—the same material as in hooves or toenails—and continue to grow throughout the life of an animal. However, the deer family is distinguished in that they carry antlers, which are composed of bone and which are produced and shed annually. The few deer species that lack antlers (such as musk deer and chevrotains), or that have small antlers, usually have enlarged, sabre-like upper canine teeth (Fox & Myers 2001).

In general only male deer develop antlers. The notable exceptions are reindeer and caribou in which both males and females carry antlers. The antlers are produced from two outgrowths on the frontal bone of the skull known as pedicles. New antlers grow with a soft furry skin called velvet and form as a cartilage-like tissue that gradually hardens to become solid bone. During the growth period, the soft parts of the antler are very sensitive and susceptible to damage from bumping against solid objects such as trees or rocks. As a consequence, stags may seek more open range to protect their antlers while they are growing. New antlers take about four months to develop and harden. The deer then carries them for about seven months until they are cast and the cycle of growth begins again. The cycle of growing and discarding antlers is controlled by the animal's testosterone levels (Harrison 1998). In young animals, first-year antlers are always small and, in the majority of cases, consist of a single spike.

All deer possess preorbital glands, situated in front of the eye, which discharge a strong-smelling secretion. Stags rub the waxy substance from these glands on trees and other objects to mark their territories. Deer also have a number of glands on their feet and legs, which they use in intraspecific communication (Fox & Myers 2001).

Some deer species are solitary, but most form herds that vary from a few individuals to a hundred or more for at least part of the year. Most species are polygynous with males competing to control groups of females. The males' antlers are used in combat to obtain and defend females during the breeding season. Females tend to be smaller and more lightly built than males, with sexual dimorphism most pronounced in highly polygynous species (Fox & Myers 2001).

Different names are used for the males, females and young of various deer species. In Australia, with the exception of fallow deer, the males of all deer species are called stags, the females are called hinds, and the young are called calves. Male fallow deer are bucks, females are does and the young are fawns (Harrison 1998). Males of all species carrying the single spike, which represents their first set of antlers, are called spikers.

Most deer pass through two coat changes during the year, the winter coat being longer and of duller colouration. These changes may be more pronounced in temperate than in tropical species. The males of some species develop a mane during the breeding season.

Female deer have four teats and normally produce one (rarely two) young. The exception is chital deer in which multiple births are not uncommon. The sex ratio at birth is usually 1:1 but this may not always hold in captivity.

2.2 Deer and domestication

While deer are kept in captivity and farmed, there is debate as to whether they meet the criteria for classification as a domestic animal. Diamond (1997) points out that over the thousands of years it took for hunter-gatherer cultures to develop pastoral and agricultural lifestyles, all the potentially useful large mammal species must have been tried as candidates for domestication on many occasions. Very few species passed the test and there are no deer species among those that did. The exception is the reindeer of Lapland. Reindeer are considered to be semi-domesticated and are owned and managed by ethnic peoples who follow the herds on their annual migrations.

Recently, the most widely accepted criterion for domestication—the ability of farmers to control breeding—has been fulfilled for a number of deer species. In some cases, this has required widespread adoption of technologically advanced methods of artificial breeding (Fletcher 2002).

Other aspects of animal behaviour—such as a species acceptance of herding and handling—are also important for domestication. Diamond (1997) identifies several characteristics of deer that make them poor candidates for conversion to domestic animals. A major failing is their nervousness and susceptibility to panic. This requires special attention to the design of fencing and handling facilities to contain the animals and minimise the chance of deer injuring themselves. Many captive deer species also need to be handled carefully, sometimes with the aid of drugs. Male deer may be extremely aggressive during the breeding season and the risk to deer handlers is increased if an animal has lost its instinctive fear of humans (Fox 1998; Fyffe 2004a).

Nor is the herding behaviour of deer comparable to that of the larger domestic animals. Some deer species are non-gregarious, and those that form herds generally do not have a well-defined dominance hierarchy. A ‘lead hind’ role has been observed in both wild and farmed red deer herds, but it is not clear how this position is achieved or maintained (Yerex 2001). There is also a tendency for farmed deer to drive out sick animals, and for some hinds to kill fawns which have been handled by humans (Yerex 2001). Such behaviours point to continuing species protection strategies, which are

contrary to the achievement of full domestication and make it difficult to manage deer in the same way as sheep or cattle.

These limitations make deer farming an operation requiring substantial commitment in time and resources to develop a profitable enterprise. They also underline the reality that, without deer fences, no sharp distinction can be made between farmed and wild deer. Over time, the selection of farmed deer for temperament and production characteristics may change this situation; however, for the moment, questions about the status of wild deer cannot be considered without also considering issues at the interface of deer farming and wild deer management. Their natural disposition means that farmed deer escaping captivity quickly revert to the wild state in a favourable environment and therefore have the potential to become part of the problem.

2.3 Wild deer species in Queensland

Of the six deer species found in the wild in Australia, four are established in Queensland: chital deer, red deer, rusa deer and fallow deer. Both Queensland species belonging to the genus Cervus (red deer and rusa) have the ability to hybridise and produce fertile offspring either with each other or with other deer species, which may be farmed in the state. This has implications for the management and declaration of wild deer populations.

2.3.1 Chital deer (*Axis axis*)

Chital (sometimes known as axis deer) are native to the Indian sub-continent and Sri Lanka.

They are a relatively small species of deer. Stags stand about 86 centimetres at the shoulder and weigh up to 90 kilograms. Hinds are smaller and weigh about 45 kilograms (Tuckwell 1998; Harrison 1998).

‘Chital’ is a Hindi word meaning spotted—a reference to the coat pattern of the species. The chital colouration varies from rusty red to dark brown with permanent white spots appearing as broken lines running along the body. A dark, dorsal stripe runs along the spine. Chital have a prominent white throat and white to beige colouring on the inner legs, stomach and under the tail. The tail is larger than in most other deer (Tuckwell 1998).

Chital stags carry three tined antlers on a long, upright beam, usually 55 to 70 cm in length, but up to 90 cm in exceptional specimens.

Chital are gregarious. They tend to live in large herds consisting of many females and their young, together with two or three stags. Breeding is non-seasonal. However, in Australia, most chital stags are in hard antler in the first half of the year and the majority of calves are born in the second half of the year (Tuckwell 1998).

Adult hinds give birth after a gestation of about 234 days (Tuckwell 1998). Twins and even triplets are not uncommon. The propensity for multiple births means there is a potential for rapid population growth. Harrison (1998) suggests that hinds with twins may raise only a single calf, the weaker calf being abandoned shortly after birth. But it is possible that a weaker calf will be abandoned more often under conditions of nutritional stress. McGhie advises that their reproduction rate is such that one chital female can give rise to twelve chital over a five year period, suggesting that twins can be successfully reared (C McGhie [RIDGE] 2004, pers. comm., 27 October).

Chital are a tropical or sub-tropical species with a strong habitat preference for woodland, forests, and clearings near waterways. The presence of permanent water is essential to chital and has a major influence on the extent of their range (Harrison 1998). They are grazers and browsers, feeding most actively at dawn and dusk and retiring to cooler areas to lie up during the hottest parts of the day. In areas experiencing cold winters, chital require adequate shelter to survive (Tuckwell 1998).

2.3.2 Red deer (*Cervus elaphus*)

Red deer are native to Europe and Asia where they occur as far east as northern Afghanistan and Tibet. A small population also exists in Tunisia. As their occupied range indicates, red deer are an adaptable species, which copes well with a range of environments from temperate to subtropical, cold and wet to hot and dry (Tuckwell 1998). This adaptability has made them a popular choice for acclimatisation. Since the nineteenth century, red deer have been introduced into Australia, New Zealand, Chile and Argentina. Their adaptability to new environments has also resulted in red deer being placed on the World Conservation Union (IUCN) list of *100 of the World's Worst Invasive Alien Species*. (Lowe *et al.*2000)

Red deer are one of the larger deer species. In Queensland populations, wild stags may stand 120 centimetres or more at the shoulder and weigh up to 220 kilograms. Hinds are smaller, around 90 centimetres, and more lightly built, weighing up to 100 kilograms (Harrison 1998; Tuckwell 1998).

Red deer are so named for their predominant coat colour. The summer coat of the species is glossy reddish brown to brown. The winter coat is longer and brown to grey. Mature red deer show a straw coloured patch on the rump. Stags develop a mane

during winter. At birth, the coats of calves carry distinct white spots, which gradually fade and disappear by about three months of age.

Red deer are gregarious but for most of the year the sexes remain apart, the older stags keeping to themselves while the hinds and younger animals form matriarchal herds, which may be led by an older female. The two sexes come together only during the breeding season, which is known as the 'rut' or the 'roar' (Harrison 1998). In Queensland, the rut commences in late March or early April and lasts for six to twelve weeks. During the rut, stags roar their challenge to other males and contest to collect as many females as they can into 'harems', which may number up to fifty hinds (De Vos 1982). Stags are very aggressive during the rut and may attack any intruders on their territory, not just other stags. It is not uncommon for stags to harass domestic stock.

Adult hinds give birth to a single calf (rarely two) after a gestation of approximately 233 days. Calving occurs from November through to January (Tuckwell 1998).

Red deer are diurnal. Their preferred habitat is open, grassy glades in forest. However, where they experience frequent disturbance, they make more use of open spaces during hours of darkness. They also make use of woody cover. Peak activity times are at dawn and dusk. Red deer are grazers and browsers. They take more woody browse and tree shoots when feed is scarce. Leaf browsing occurs in spring and summer (De Vos 1982).

2.3.3 Rusa deer (*Cervus timorensis*)

Rusa deer are native to South-East Asia, 'rusa' being the Malay word for deer. Rusa are also known as 'Sunda sambar'. They are placed in the same subgenus (Rusa) as the sambar deer (*Cervus unicolour*) which are found in southern Australia.

Rusa are widespread in the Indonesian archipelago from where they have been introduced into south-east Kalimantan, New Guinea, the Bismarck Archipelago, New Caledonia, Australia and New Zealand. Two subspecies are found in Australia: Javan rusa (*C. timorensis russa*) are established in Royal National Park outside Sydney and surrounding areas; Moluccan rusa (*C. timorensis moluccensis*) are found on the islands of Torres Strait. Recent introductions of farmed rusa into other parts of Queensland are predominantly the larger-bodied Javan rusa or Javan rusa hybrids.

Rusa are a medium-sized species of deer. Javan rusa stags may stand 110 centimetres at the shoulder and weigh around 120 kilograms. Hinds are up to 95 centimetres at the shoulder and weigh up to 80 kilograms (Harrison 1998; Tuckwell 1998). Moluccan rusa are slightly smaller.

The rusa coat varies from greyish to yellowish or reddish brown, shading to darker brown on the hindquarters. The body hair is coarse and somewhat sparse when compared with other deer. Stags develop a mane during winter. New calves have a rich red coat.

The antlers of rusa are typically three tined with the beams forming a characteristic lyre shape.

Rusa, like red deer, are gregarious. However, they differ from red deer in that they have no definite breeding season. Rather, while there is a tendency for breeding to occur from June to October, individual hinds may cycle earlier or later. Because of this, rutting may take place at any time and hinds may produce three calves in two years. There is also less of a tendency for rusa to fight during the rut. Instead rusa stags 'plough' vegetation and amass large bundles of greenery on their antlers, which they use to establish dominance over other males (Harrison 1998).

Adult hinds generally give birth to a single calf—although twins are not uncommon—after a gestation of about 252 days. Most calves are born around March and April (De Vos 1982; Tuckwell 1998; Harrison 1998). Studies of rusa deer in New South Wales suggest that fecundity is high with 75 per cent of hinds giving birth and 50 per cent of all fawns surviving their first year of life (Moriarty *et al* 2001). The high level of fecundity and ability to produce three calves in two years means that rusa have the potential for rapid population growth.

Rusa are a tropical species. They are semi-nocturnal. Their preferred habitat is grassy plains bordered by dense brush or woodlands to which they can retire during daylight hours. They are preferential grazers of grass, but also browse depending on season and availability of food. Being a tropical species, rusa do not cope well with cold weather and require adequate shelter and high energy feed to survive in cold conditions (Tuckwell 1998).

2.3.4 Fallow deer (*Dama dama*)

Fossil records indicate that fallow deer were widely distributed across what is now continental Europe and the British Isles prior to the last ice age. It is not known exactly when the species began to recolonise Europe following the melting of the ice, but human intervention has played a major role in establishing its current distribution. Fallow deer have been maintained in semi-captive conditions by different cultures for millennia and there is evidence that the Phoenicians and Romans assisted their reintroduction to parts of the Mediterranean and western Europe. More recent historical accounts record the continuing spread of fallow deer by the Normans and other members of the European nobility for hunting purposes. The result is that fallow deer

once again have a wide distribution in Europe. But at the same time human intervention has resulted in a number of changes in the animal commonly recognised as fallow deer.

There are two recognised subspecies of fallow deer:

- European fallow, sometimes known as park deer, (*Dama dama dama*), are believed to originate from the Mediterranean region of Europe and Asia Minor. This subspecies is found in the wild and in captivity in most European countries. However, all populations now in existence are believed to have been sourced from managed herds; that is, the subspecies, which provided the rootstock for these populations, no longer exists in the wild. European fallow have also been introduced into the United States, Australia and New Zealand, where wild populations have formed.

- Mesopotamian or Persian fallow (*Dama dama mesopotamica*) originate from Iran and Iraq. A small number of Mesopotamian fallow may still be found in Iran but the subspecies is virtually extinct in the wild and listed as an endangered species by the Convention on International Trade in Endangered Species (CITES) (Tuckwell 1998). Captive populations have been established to ensure the survival of the subspecies.

Fallow are a smaller species of deer with European fallow bucks standing about 90 cm at the shoulder and weighing around 90 kg. Does stand around 76 cm at the shoulder and weigh up to 42 kg (Tuckwell 1998; Harrison 1998). Mesopotamian fallow are taller and heavier than the European subspecies (Tuckwell 1998).

'Fallow' is an obsolete Old English word meaning 'reddish-yellow'. This is reflected in the common coat colour of both European and Mesopotamiam fallow. However, selective breeding in semi-captive populations has led to the development of a wide variety of coat colours in European fallow. This is the most distinctive feature of the subspecies. European fallow occur in four colour varieties:

- The common coat colour is tan or fawn with white spotting on the flanks. The tail is long, black on top and white beneath. It is surrounded by a white rump patch, outlined with a characteristic black horseshoe. In winter the coat is longer and greyer with indistinct spots.

- The Menil variety has a paler coat and keeps its white spots all year. It lacks the black-bordered rump.

- The melanistic variety is almost entirely chocolate to black with no white colouration.

- White fallow are white to sandy in colour, with the coat becoming whiter at adulthood. The white variety is a true colour and not albinism.

Mesopotamian fallow do not show the same colour variation as European fallow. Their colour can be described as white spots on a light rusty brown background (Tuckwell 1998).

Historically, the ranges of the two subspecies appear to have overlapped and they are closely related genetically. In captivity European and Mesopotamian fallow hybridise freely and all offspring are fertile.

The antlers of adult fallow bucks (over three years) are flattened and palmate with numerous points, increasing in size with age. Antlers may be up to 70 cm long.

Fallow deer are gregarious. Like red deer, mature bucks live apart from the does until the start of the rut. During the rut, dominant bucks herd groups of does, mark out territories and rutting stands, and mate on their territories (Drew 1996). Fallow bucks are very aggressive and can be dangerous when rutting (Tuckwell 1998; Harrison 1998). However, fallow deer as a species are also extremely timid and nervous. They display a bouncy gait when alarmed (Tuckwell 1998).

The breeding season for fallow deer in Australia is similar to that for red deer. The season usually begins in April and lasts 6 to 8 weeks. Males remain aggressive until early August (Tuckwell 1998).

Adult does give birth to a single fawn (rarely two) after a gestation of about 230 days (Tuckwell 1998). Fawns are born with a coat similar to the summer coat of the adult.

Fallow deer are a temperate species and less suited to hot conditions than some other introduced deer species. They are diurnal but may make more use of open spaces during hours of darkness in areas where they experience frequent disturbance. Peak times of activity are at dawn and dusk. Very young fawns do not tolerate extreme heat and require access to well shaded areas (Tuckwell 1998).

In Europe, fallow deer inhabit mature deciduous mixed woodland with dense undergrowth. They feed in open, grassy glades or on forest margins. They also occur in marshes, on agricultural land, and in mature conifer plantations. In Australia, forest country with dense understorey is a favoured retreat.

Fallow deer are grazers and browsers. Trees and shrubs are browsed more when feed is scarce. Where fallow are found in agricultural areas they may cause damage to orchards and crops in times of feed shortage.

3. History of deer in Australia

3.1 Introduction and spread

The first deer introduced into Australia appear to have been chital imported from India in the late eighteenth or early nineteenth century (Tuckwell 1998; Biosecurity Australia 2003). However, the major spate of introductions took place from the 1850s onwards when a total of eighteen different deer species appear to have been introduced. In some cases, several subspecies of the same deer were released at the same or different sites.

Twelve of these species failed to establish themselves. The failed introductions included swamp deer (*Cervus duvaucelli*), Bawean deer (*Axis kuhlii*), sika deer (*Cervus nippon*), Chinese water deer (*Hydropotes inermis*), mule deer (*Odocoileus hemoinus*), musk deer (*Moschus sibericus*), reindeer (*Rangifer tarandus*), Eld's deer (*Cervus eldi*), white-tailed deer (*Odocoileus virginianus*), muntjac (*Muntiacus muntjak*), roe deer (*Capreolus capreolus*), and barasingha (*Cervus duvauceli*) (Bentley 1998; Groves and Bishop 1989). The remaining six species—those found in established wild populations in Australia today—include chital, hog deer, red deer, rusa, sambar, and fallow deer. But not all of the species that became established were successful at every release site. Nor was every subspecies successful; for example, attempts to introduce wapiti or elk (*Cervus elaphus canadensis*)—a subspecies of red deer—failed even though red deer introductions were successful.

There are a number of reasons for this lack of success. Often only a small number of animals (perhaps as few as three: one male and two females) were released. One early death or failure to find suitable feed and shelter quickly and the introduction would be doomed. A poor match between the species and the environment of release appears to have been the major cause of such failures.

Even with the six deer species that went on to establish viable wild populations, not all were released into environments that were ideal for their requirements. This resulted in a patchy distribution which reflected the initial release sites rather than areas into which deer subsequently dispersed (Wilson *et al* 1992). While it may not have been the intention of those responsible for the introductions, this appears to have limited population growth. In 1980 it was estimated that Australia had fewer than 50 000 wild

deer in about 20 populations, mostly in the eastern part of the continent (Standing Committee on Agriculture 1980). The historically well established populations included:

- chital deer around Charters Towers in northern Queensland
- red deer in south-east Queensland and the Grampians district of Victoria
- rusa deer, with the Moluccan rusa subspecies in the Torres Strait and Javan rusa in and around Royal National Park outside Sydney
- fallow deer with a major herd in Tasmania and populations on the New England Tableland, in southern Queensland, and various locations in Victoria and South Australia
- sambar deer in several mountain locations in Victoria, contiguous areas of southern New South Wales, and on the Coburg Peninsula in the Northern Territory
- hog deer in southern coastal Victoria.

Of these species, only sambar have been assessed as capable of extending their range unaided (Standing Committee on Agriculture 1980). For some time, the expanding sambar population has been moving slowly northward from Victoria, colonising new areas along the Great Dividing Range.

In addition to wild deer, it was estimated that there were also 8 000 to 9 000 commercially farmed deer in Australia in 1980. These animals were in addition to those in zoos and wildlife parks, or those held privately by deer fanciers (Standing Committee on Agriculture 1980). But at about this time the numbers of deer both behind wire and in wild populations began to grow.

The increase was fuelled by deer farming, which grew rapidly as an industry throughout the 1970s and 1980s. A trapping industry emerged to catch wild deer for supply to farmers and those farmers, in turn, developed breeding programs that saw farmed deer grow rapidly in numbers. According to the Rural Industries Research & Development Corporation (2000), the number of farmed deer increased annually by about 25 per cent up to the early 1990s.

At the same time, recreational deer hunting in Australia was also growing. RIDGE (2003) attributes this in part to raised awareness of deer hunting among the general public due to increased coverage of the topic in books and magazines. But the heightened interest may also be an indirect result of recent changes to firearms

licensing requirements. The number of individuals in Australia with an interest in hunting has always been high and runs into the hundreds of thousands. New licensing requirements introduced in the 1990s increased recreational firearms club membership and brought more people into contact with information on topics such as deer hunting. Cause (1995) reports a 1990 survey that suggested there were 17 500 deer hunters in Australia. Many in the industry considered this to be an underestimate at the time and it is certainly not indicative of current numbers. In Victoria alone there was a 60 per cent increase in licensed deer hunters to more than 11 000 in the eight year period to 2004 (Australian Deer Association and Parks Victoria 2004).

It was against this background that the market for farmed deer products crashed in the early 1990s. The crash was accompanied by prolonged drought—lasting in some areas to 1998—and the consequent slaughter of large numbers of breeding females sold at very low prices. These factors combined to decrease confidence in the industry. The RIRDC (2000) reports instances of whole herds being sent for slaughter.

This crash in deer farming also saw many deer pass back into the wild. Some animals escaped and were not recovered. Others were liberated as the cost of feeding them began to outweigh their value, even for slaughter. Some were purchased from farmers or trappers, to be released by those wishing to create their own populations for hunting or aesthetic reasons (Moriarty *et al* 2001). Prior to the growth in deer farming, such practices had been limited by the availability of stock for release (Glover 2000; RIDGE 2003; Moriarty 2004). Whether by escape or deliberate release, new populations were rapidly established, many of them in areas previously free of wild deer.

Not all deer farmers were discouraged. The RIRDC (2000) estimates that growth in the number of farmed deer continued at a reduced rate—probably less than 10 per cent — after 1993. This, in combination with new releases of deer, saw the number of deer in Australia continue to increase. The Deer Farmers' Information Network (2003) and Austrade (2004) placed the number of farmed deer in Australia in recent years at a little under 200 000. Moriarty (2004) estimated that Australia had another approximately 200 000 wild deer in 218 populations.

There are a number of issues arising from this evidence of the increase in deer numbers and spread of wild deer that are relevant to the status of deer as a pest.

Moriarty (2004) estimates that 85 per cent of the wild deer in Australia are accounted for by the long-established acclimatisation society herds. Escapes from deer farms account for 6 per cent and translocated animals 9 per cent. Taking into account the estimates of the Standing Committee on Agriculture (1980) and Moriarty (2004), this suggests that deer in acclimatisation society herds increased in number from fewer than 50 000 in 1980 to approximately 170 000 in 2004. While there may be differences

in the way populations were estimated between 1980 and 2004, it is also possible that, between those years, changes in the way wild deer were managed enabled some populations to increase beyond the critical threshold below which they previously had been held by hunting and natural predation. There is also historical evidence and research data showing rapid population growth for deer when new areas are colonised and conditions are suitable (Harrison 1998; Moriarty *et al* 2001).

If the increase in Australian deer numbers is now outstripping the harvest rate, then Moriarty's data on the geographical spread of deer gives more cause for concern. Moriarty (2004) reports that, of the 218 identified wild deer herds in Australia, only 7 per cent were established from acclimatisation society releases. Although the Standing Committee on Agriculture (1980) expressed the view that escapes of farmed deer were likely to be of little consequence, Moriarty (2004) identifies 35 per cent of current wild deer populations resulting from recent deer farm escapes or releases. And although Australia's Council of Nature Conservation Ministers had agreed that no new wild deer range should be created by the impact of deer farming (Standing Committee on Agriculture 1980), Moriarty's data indicates that the remaining 58 per cent of current populations have arisen from translocations of farmed deer or wild deer captured for the purpose of translocation.

This assisted dispersal of deer—contrary to nature conservation policy—has the potential to compound the problem of rapidly multiplying numbers. Moriarty (2004) points out that the predicted (bioclimatic) distributions for the six established species suggest that deer do not yet occupy all suitable habitats in Australia. Moriarty concludes that chital, sambar and hog deer in particular have 'immense scope to expand their distributions' (Moriarty 2004). Much of the apparently suitable habitat for these species lies within Queensland.

There is a view of wild deer as a valued game animal and an appealing addition to the Australian environment (Harrison and Slee 1995; Bentley 1998; RIDGE 2003). But this needs to be weighed against reports of deer causing agricultural and environmental damage (Low 1999; Glover 2000; Moriarty *et al* 2001; *Stanthorpe Border Post* 2002; Woodward 2002; *Brisbane Valley-Kilcoy Sun* 2003; Morley 20003a; Hennessy 2004; *Advocate* 2004; Schoer 2004) and as potential carriers of stock and wildlife diseases (Glover 2000; Hammond 2000; *Brisbane Valley-Kilcoy Sun* 2003; Morley 2003b; Biosecurity Australia 2003). The presence of wild deer may also have social consequences, as evidenced by reports of deer causing damage to parks and gardens in outer urban areas and as traffic hazards on major roads (Glover 2000; Woodward 2002; Morley 2003a). Concern for such issues rises with the increasing spread of deer.

3.2 Legislative status—national

The importation of deer and deer genetic material into Australia is restricted for reasons of animal health under the Commonwealth *Quarantine Act 1908* and subordinate regulations. The Department of Environment and Heritage also exercises regulatory control over plants and animals, which are classified as suitable for live import and issues permits for the importation of identified species. The regulations are established under the *Environment Protection and Biodiversity Conservation Act 1999*, section 303. There are no deer species that do not require an import permit and four species listed that require a permit. For three of these species—red deer (*Cervus elaphus*), sika deer (*Cervus nippon*), and wapiti or elk (listed in the regulations as *Cervus canadensis* but more usually identified as a subspecies of red deer, *Cervus elaphus canadensis*)—no conditions are imposed for importation. The fourth species—Philippine Spotted Deer (*Cervus alfredi*)—may be imported for 'eligible non-commercial purpose only, excluding household pets'—and must be housed in high security facilities. Apart from these Commonwealth controls on imports, legislation affecting deer is the responsibility of individual states.

Prior to the emergence of deer farming, the main thrust of state legislation was to conserve or manage wild deer populations. However, there was considerable variation between states in the way they approached this issue. Legislation ranged from the full protection of all deer species, to partial protection, to no protection at all. In some states deer hunting was permitted by licence in declared hunting seasons. In all states, deer hunting was pursued, irrespective of the law.

The emergence of deer farming brought pressure for legislative change. But still there was no consistency in the states' responses. Some states sought to bring farmed deer under existing legislation for domestic stock. Others looked to New Zealand, where deer farming had provided the incentive for an Australian industry, and drew up new legislation based on the New Zealand approach. The only consistency was that, in general, the control of deer in Australia remained in the hands of wildlife authorities while matters associated with animal health and slaughter were in the hands of agricultural authorities. The Standing Committee on Agriculture (1980) questioned the workability of such a separation of responsibilities in the longer term.

Where deer-farming legislation was introduced, the primary purpose was to regulate matters such as localities in which deer could be farmed, identification of animals, fencing and stock movement. However, some in the industry felt that regulations, which went beyond the requirements for other stock, were unreasonably restrictive. In time, this pressure led to deer farming legislation being repealed. But the legislation did not, and perhaps could not, anticipate the problem that would arise with farmed deer that were no longer wanted or with a deer trapping industry that could serve other markets if

demand from deer farmers declined. Thus the repeal of deer farming legislation exacerbated a new problem, already growing but not formally identified: increasing wild deer numbers and populations resulting from deer farm escapes, releases and deliberate translocations.

In recent years, Tasmania, Victoria and New South Wales have moved to manage wild deer as game and have involved recreational deer hunters in the process. In these states, wild deer are partially or fully protected by legislation, with annual or restricted open seasons (Moriarty 2004). In other states and territories, wild deer are classified as non-indigenous or exotic animals. In these cases, deer may or may not be declared and controlled as pest species. There may also be provision for hunting or sustainable harvest (Hall 1999). But even in the states where cooperative management systems exist, the focus is mainly on the historically established wild deer populations.

The three states that manage deer as game have each adopted different approaches:

- In Tasmania, the main deer hunting areas are on private land. The state has developed a management system for fallow deer hunting and pest control founded on Property Based Wildlife Management plans (PBWM), implemented by agreement between landowners and hunters, and facilitated by the state's Game Management Services Unit. This cooperative approach is held up as a model for wildlife population control generally (*Agriculture Tasmania* 1999).

- In Victoria, most licensed deer hunting takes place on public land. For many years, hunters' licence fees have been applied to wetland rehabilitation to support the species hunted and wildlife generally (Harrison 1998). But a step towards direct cooperation between hunters and government regulators was taken on 1 July 2004, when the Australian Deer Association (Victoria) and Parks Victoria signed a Memorandum of Cooperation to preserve and enhance recreational deer hunting and to apply science for the management of wild deer populations on state controlled lands.

- In New South Wales a separate statute regulates game hunting. This is the only jurisdiction where this occurs. The *Game and Feral Animal Control Act 2002* was set up to provide for the effective management of introduced species of game animals as well as feral animal control. The Act establishes a sixteen-member Game Council with membership comprising eight representatives from government, wildlife management science, veterinarians, and the Aboriginal Land Council, and eight representatives from hunting organisations. The Game Council administers the game licence system in New South Wales, represents the interests of licensed game hunters, and liaises with other agencies on issues such as feral animal control. The Council is able to apply funds from

licences to research and conservation projects, as well as for the conservation of game species and control of feral animals. It is developing a policy on property-based wildlife management similar to that in Tasmania, and negotiating access to state owned lands for appropriately licensed recreational hunters to hunt feral animals (Game Council NSW 2004).

The common thread in these approaches is a preference for arrangements in which landholders (both public and private) and hunting groups cooperate with each other and the legislature in developing and implementing systems to address objectives in deer harvesting and wider environmental concerns. Unfortunately, however, the legislative separation of responsibility for the management of deer persists. The NSW National Parks and Wildlife Service has formulated natural resource management plans for many areas of the state, including plans to eradicate newly established populations of feral deer. But the Game Council is not involved in that planning. The deliberate release of deer is an offence in New South Wales. But, if new populations of deer become established, the Game Council's only concern is for their management as game (R.Borsak [Game Council NSW] 2004, pers. comm., 23 October). This points to a continuation of the separation of responsibilities, which the Standing Committee on Agriculture (1980) suggested would not be workable in the longer term.

Greater coordination of legislation for hunting and pest control will be required to address emerging issues with deer and other feral animals in Australia. Those issues include responses to the suggested development of an Australian safari hunting industry based on exotic game and feral animals (Dryden and Craig-Smith 2004). Experience in New Zealand (K. Briden [Department of Conservation, New Zealand] 2004, pers. comm., 9 December) suggests that the promotion of this industry has the potential to further exacerbate the problem of increasing numbers of wild deer (and possibly other exotic species and feral animals) unless industry development takes place with appropriate consultation and regulatory safeguards. However, as Moriarty (2004) points out, the concept of overabundant deer is relatively new in Australia and the lack of effective legislation to address the issue is only part of the problem.

4. Legislative status and distribution of deer in Queensland

4.1 Legislative status—Queensland

One of the primary motives for the introduction of deer to Queensland was recreational hunting and/or as an alternative food species for regional populations. There is anecdotal evidence that, in the early years following the release of deer, many people hunted deer and used the resource in these ways. From the early twentieth century,

varying degrees of protection were applied to certain native animals under legislation such as the *Native Animals Protection Act 1906* and the *Animals and Birds Act 1921*. But the *Fauna Conservation Act 1952* also included deer within the legal definition of fauna. Under the Act, all deer in Queensland were declared protected species and property of the Crown.

The main effect of the protected status was to outlaw recreational deer hunting. Landholders were able to apply for destruction permits where deer were a local pest. However, pest destruction had never been the primary motive for deer hunting. As a result, with a strong hunting community and deer a highly prized game animal, deer hunting in Queensland continued illegally with the acquiescence and participation of many landholders (Searle and Parker 1982).

The protected status conferred on deer continued under the *Fauna Conservation Act 1974.* But this Act was amended during the time it was in force, to recognise the emergence of deer farming. In time, persons intending to farm deer within the deer distribution range were able to obtain permits to trap deer and convert them to farmed animals. A royalty was paid for each deer caught (Searle and Parker 1982).

While captured animals commanded high prices, this led to changes in the landholder view of deer, although not necessarily while observing the Act. The RIDGE Group (2004) suggests that most landholders throughout the deer range held the view that deer were eating their crops and pasture without any compensation forthcoming from the Crown, therefore the Crown had no right to claim a royalty. As a result—and as with deer hunting previously—the regulations were largely ignored. RIDGE (2004) describes a rapid growth in trapping, with well over a hundred deer traps operating in south-east Queensland, and a resulting rift between hunters and landholders over access for hunting. Hunting became more difficult, but with an entrenched tradition of illegal hunting, there was no reduction in the overall harvest of red deer.

This situation did not assist efforts to legalise deer hunting as pressure for access began to mount. Regulations under the Act introduced a limited open red deer season in 1976 and a regular season from 1979. This brought the state broadly into line with the approach in some other states. But the Queensland system was more complicated. Hunters were required to apply for a permit and deer tags, and landholders were required to state that deer were causing damage and apply for a pest destruction permit (RIDGE 2003). Few permits were applied for but this was more a reflection of the belated attempt being made to license hunting than an indication of the hunting taking place. Those who already had access, and were hunting deer illegally, were able to ignore the permit system. For outsiders, while deer hunting was legalised under certain conditions, in practice there was little hope of gaining legal access.

The management of wild deer in Queensland was further affected by the Deer Farming Act. This Act laid down requirements for the identification of farmed deer, the fencing of deer farms, and the movement of deer. It also provided for the declaration of feral areas for the four species of wild deer found in Queensland at that time, corresponding to the geographical ranges established by the original releases. The Act established three classes of annual deer farm licence based on those areas and the type of deer farmed:

- feral area, for farms where deer were kept within the declared feral area for their species
- non-feral area, for farms where deer were kept outside the declared feral area for their species
- combined, for farms keeping deer within their declared feral area plus deer of any other of the prescribed species.

The Chief Inspector of Stock, Department of Primary Industries, was to be notified about escapes of farmed deer.

These provisions reflected a view that, while the Act should present no impediments to deer farming, neither should deer farming lead to the further spread of feral deer or to the establishment of new wild populations outside the declared feral areas.

However, although the Deer Farming Act indicated a legislative intention to manage deer in Queensland, the separation of responsibility between various Acts did little for efforts to coordinate management issues. The course of events leading to the current rapidly increasing feral deer populations began when the *Fauna Conservation Act 1974* was replaced by the *Nature Conservation Act 1992*.

Deer were excluded from the coverage of the Nature Conservation Act, removing their protection. This caused alarm among parties with an interest in the status of wild deer. Landholders, hunting groups and local government councils all expressed concern, particularly about the implications for recreational hunting should wild deer be accorded similar standing to pests such as feral pigs or cats (Australian Deer Association 1994; RIDGE 2003). The change in status was completed when Schedule 5 of the Rural Lands Protection Amendment Regulation (No. 1) 1994 declared seven species of deer—the six species already established in Australia, plus wapiti or elk (*Cervus elaphus canadensis*)—in categories A4 and A6 under the Rural Lands Protection Act. This made it an offence to introduce, sell or keep the species without a permit, and was aimed at preventing the spread of wild deer. However, deer were not declared under

category A2, which would have required landholders to control the animals on their land.

Farmed deer were not affected by the declaration of deer under the Rural Lands Protection Act. But in 1995 the Deer Farming Act was repealed following what RIDGE (2003) describes as 'constant pressure to relax restrictions that were seen as stifling the deer industry'. The licensing requirements for deer farms in non-feral areas were among the restrictions objected to. Following the repeal of the Act, farmed deer were covered only by legislation applying to livestock generally. This was followed in 1997 by amendment to the Rural Lands Protection Amendment Regulation (No. 1), which removed wild deer from the list of declared animals. This meant that, other than legislation for livestock generally, there was no longer any Queensland legislation applying to deer specifically and no restriction on the introduction, sale or keeping of the animals. Deer were deemed to be a regional issue. Local governments had the option to declare deer under local law where the animals were a problem.

It was at this time in the mid-1990s that a decline in the profitability of deer farming and widespread drought created the situation where wild deer began to proliferate. The protected status and restricted access to deer in the past had created an unmet demand, which could now be satisfied by the availability of unwanted farm animals and an established deer trapping industry. With no state legislation regulating activity, there was no barrier to the establishment of new deer herds. Thus the changing status of deer over time and changes to the regulations and economics of deer farming created circumstances in which a potential pest species began rapidly increasing in numbers and distribution across the state.

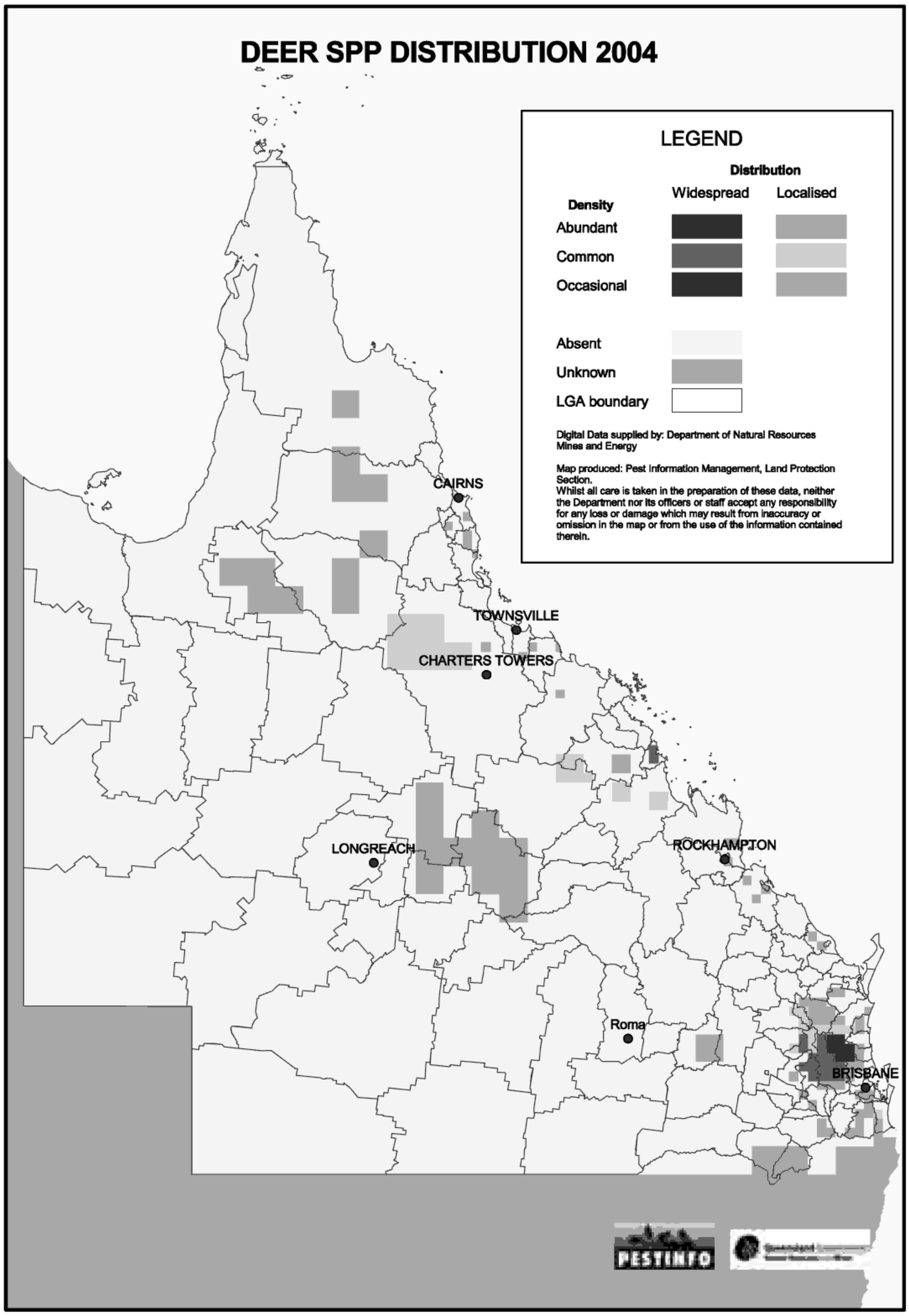
Regulations established under the Land Protection (Pest and Stock Route Management) Act continue to exclude from the list of declared animals eight species of deer, which are those most likely to be farmed or found in Australian zoos. These are the six species of deer historically established in the wild in Australia, plus wapiti/elk and white tailed deer (*Odocoileus virginianus*). But the increasing numbers and distribution of deer, combined with demands from various interests for wild deer to be controlled, managed or protected, suggests the need for a review of the issues and the development of possible management and control strategies.

4.2 Current and potential distributions

The Queensland Acclimatisation Society was active in the introduction of deer to the state throughout the latter part of the nineteenth century. An examination of the current distribution of deer in Queensland reveals the major deer herds still centred on sites of successful introduction. However, as discussion of the legislative status of deer in

Queensland shows, in recent years a number of factors have contributed to expand the distribution of deer across the state.

Map 1: Reported deer species distribution in Queensland, 2004



Source: NRM&E 2004, Annual Pest Assessment

Deer were included for the first time in the Department of Natural Resources and Mines 2004 Annual Pest Assessment. This survey gathered reports of deer from many areas outside the traditional deer range, which had been defined as the feral areas under the Deer Farming Act. The 2004 Annual Pest Assessment results for deer are presented in Map 1. The map does not provide a complete picture of the distribution of deer in Queensland. Nor does it identify the deer by species. Further populations have been identified and, in some cases, more than one species of deer has been found in the same area. Nevertheless, the known distribution of deer in Queensland considered in conjunction with bioclimatic data suggests that some new deer populations have a potential for rapid expansion.

4.2.1 Chital deer

The first significant introduction of deer in Queensland appears to have been a release of chital on the Darling Downs in 1870. However, this herd did not survive. A subsequent release at Maryvale Station near Charters Towers in 1886 led to the establishment of the species on several properties in that area. Historically, local landholders have managed these deer, with some access for recreational hunters and trapping for deer farming. According to RIDGE (2003) chital numbers in this population increased up to the 1990s with favourable seasons and limited trapping pressure. But, numbers were subsequently reduced by professional venison shooters and the effects of prolonged drought.

Although much of inland Queensland appears climatically suited to chital, until recently the deer were concentrated in an area surrounding their original release point. The Standing Committee on Agriculture (1980) concluded from this that the animals preferred ‘soft’ country—fertile and well-watered—and harder country to the south had prevented them from spreading downstream into the Burdekin valley. RIDGE suggests that drought has led to wider dispersals of chital in recent years. But translocations and escapes of farmed chital have also been identified (Moriarty 2004).

Harrison (1998) observed that it was ‘extremely doubtful if chital exist anywhere in Australia outside of the North Queensland habitat’. However, Moriarty (2004) identifies fourteen separate chital populations in Queensland and another thirteen in New South Wales, Victoria and South Australia. Most are currently small populations arising from recent releases. But some Queensland herds are substantially larger and geographically widely dispersed.

Case study: The Rita Island chital

Rita Island lies at the mouth of the Burdekin River. It is a section of flood plain cut off by an anabranch of the river, which fills during floods. The island is used for sugar cane, small crops and cattle production. It is about nine thousand hectares in area.

About 20 chital arrived at Rita Island in the late 1970s (Standing Committee on Agriculture 1980). There is debate as to whether the deer were translocated or arrived through natural dispersal from up river. The animals multiplied and by the 1990s were in sufficient numbers to cause damage to grazing and cropping enterprises in the area. Concerns were regularly voiced in the local media (e.g. *Advocate* 2004).

The Rita Island chital have spread from their point of origin to occupy the belt of mangroves and tidal flats extending inland from the ocean front. Chital are a water-loving species, well-suited to such an environment. From the mangroves they move out into agricultural areas in search of feed during dry times in late winter and early spring. This is the typical pattern where deer are a seasonal pest.

Rita Island was inspected on 23 November 2004. About 200 – 300 chital were seen in large and small herds at several locations. Signs of chital were seen along all watercourses, including damage caused to saplings by antler rubbing. Thus the deer are causing damage to the natural environment as well as to agricultural crops. Based on the sightings and information from local residents it was estimated that there could be 2 000 or more chital on Rita Island.

The management of these chital has been a contentious issue for some time. In the past, the owner of the property from which the chital originated has resisted attempts to control the animals. This has led to confrontations with other landholders. There has also been a problem with illegal shooters spotlighting in the area at night. As Rita Island is flat and relatively closely settled, the shooting presents a safety risk for residents.

More recently, the Lower Burdekin Chital Management Group has been formed to provide a coordinated response to the issue. The owner of the property from which the chital originated has accepted that some management action is necessary and has begun to erect deer fences on his property. Illegal shooting has declined since the group became active. Other landholders have begun to erect deer fences to prevent the chital gaining access to their properties from the mangroves.

Although Rita Island has a substantial chital population, the deer are in a confined area and eradication is a possibility. The cost of eradication might be offset if the animals were shot for meat.

In Queensland, in addition to the original acclimatisation herd near Charters Towers, five chital populations appear to have become established from deer farm escapes or translocations in the general area around Townsville and Charters Towers. Another seven populations in the Gulf, and from Charters Towers down through Central Queensland are attributed to translocations. The main Charters Towers herd is known to number many thousands of animals. Commercial hunting operator, Jim Peterson estimates that as many as 10 000 chital died in a recent drought (J Petersen 2004, pers. comm., 15 December). Numbers have since recovered. There is also an estimated 2 000 chital on Rita Island at the mouth of the Burdekin. Populations in the hundreds have been identified in the Gulf and near Texas on the southern border.

Bioclimatic data suggests that most of Queensland—indeed, most of Australia—could provide suitable chital habitat provided the requirement for access to water is met. The mushrooming of successfully translocated herds in Queensland and other eastern states since the 1990s tends to bear this out. When the high reproduction rate of chital is taken into account there may be potential for rapid population increases in the future under favourable seasonal conditions.

4.2.2 Red deer

Red deer were also an early introduction to Queensland. Released in 1873 by the Queensland Acclimatisation Society with the consent of the Queensland Government, the original animals were a gift from Queen Victoria to provide '…additional food and sport' for the people of the state. The initial release of six hinds and three stags occurred at Cressbrook near Esk, with a further release in 1874. English and German strains of red deer comprised the first release, with the possibility of a Scottish strain being introduced at a later date (McGhie and Watson, 1995). Although originating from a temperate environment in northern Europe, the deer have adapted well to sub-tropical conditions in southeast Queensland. From their initial release point, they have spread throughout the upper reaches of the Brisbane River valley and into the headwaters of the Mary and Burnett Rivers.

The most recent estimates of the wild red deer population in southeast Queensland put the number at 10 000–15 000. Up until the 1970s, this herd was managed by landholders. Pest populations were culled under permit but numbers were also controlled by both legal and illegal recreational hunting (McGhie and Watson 1995). Red deer were the species most affected by the emergence of deer farming and changes to deer legislation after the 1970s. Red deer are a large animal and a preferred species for deer farming. They are also a premier game animal.

With the emergence of deer farming in the 1970s and the opportunity to reap an economic return from wild deer on their land, some landholders in Queensland's red

deer area opted to fence in the wild herds on their properties and farm the animals commercially. Others trapped red deer to sell to deer farmers. More recently, some landholders have capitalised on the opportunity to earn revenue by providing recreational hunters with access to wild deer on their land.

According to RIDGE (2003), the red deer population in Queensland is 'presently keeping to a low rate of natural increase'. However, there is evidence that the deer have expanded their range in recent years. In many cases, it is not clear whether (as has been suggested with chital) this reflects dispersion in response to a series of prolonged droughts, or whether new populations have been created by releases or escapes from deer farms (Morley 2003a). Moriarty (2004) identified two Queensland red deer populations established by translocations: one (with a population of fewer than 100 animals) in the Rockhampton region and one (with a population between 100 and 500) in the Roma-Injune-Mitchell area. Tom Garrett (President, Queensland Macropd and Wild Game Harvesters Inc.) reports two separate populations in this area: one located between Roma and Injune and one near Mitchell (T. Garrett 2004, pers. comm., 19 November). Regular sightings also suggest that red deer are expanding their range into environments contiguous with Queensland's historic red deer area, including the outer suburbs of Brisbane (M De Glas [Brisbane City Council] 2004, pers. comm*., 22 November*; Morley 2003a).

A large part of southern Queensland appears to offer suitable habitat for red deer. In the past it was considered that agricultural activity on the boundaries of the traditional red deer range formed an effective barrier to further expansion. But the recent assisted dispersal of red deer, coupled with the placement of the species on the World Conservation Union (IUCN) list of *100 of the World's Worst Invasive Alien Species* (Lowe *et al.*, 2000) sounds a note of caution. Recreational hunting groups have argued for the introduction of new genetics to improve the quality of Queensland red deer trophies (RIDGE 2003). But such action would increase the genetic diversity (and possibly the adaptability) of a recognised pest species. Unless an appropriate management system was in place, any introduction of new genetics, coupled with the current assumed 'low rate of natural increase' and observed expansion of range, could pave the way for more rapid population increases and spread of red deer in the future.

4.2.3 Rusa deer

The last of the official release of deer in Queensland was the introduction of rusa deer to Friday Island in the Torres Strait in 1912. This release took place with the permission of the Commonwealth Government. The deer later swam or were transported to other islands including Prince of Wales Island which now supports the major population

Case Study: Deer in the suburbs—the Pinjarra Hills – Mt Ommaney area

The western suburbs of Brisbane are linked with the red deer area of the upper Brisbane Valley by contiguous stretches of national park, state forest and other undeveloped Crown land. These public lands have always been available as a corridor for the expansion of red deer from their original release point. Until recently, however, only occasional individuals had been sighted passing through the area.

In the last decade, a continuous deer presence has developed in the outer Brisbane suburbs of Pinjarra Hills and Mt Ommaney. In addition to growing numbers of red deer, a large population of rusa has appeared. The rusa are believed to originate from a deer farm. The origins of the red deer are less certain. They may be from a deer farm or they may have dispersed from their traditional range at the head of the Brisbane Valley during recent periods of prolonged drought.

In 2003, the increasing deer numbers became a problem. A herd of rusa was sheltering in bushland at Pinjarra Hills and emerging at night to feed in suburban gardens and on pasture at the nearby University of Queensland's veterinary science campus. Damage was caused to horticultural enterprises and young trees planted for bushland rehabilitation. Deer were also implicated in number of vehicle accidents.

An inspection of the University of Queensland site on 25 November 2004 revealed some deer tracks and erosion of the river bank caused by hoofed animals. Deer were said to swim to the Mt Ommaney side of the Brisbane River to feed from time to time. An inspection of the opposite bank showed some old deer browse and scats.

Control of deer in such situations presents a challenge. Brisbane City Council removed 53 rusa in a trapping program in 2003. These were relocated to captivity at the University of Queensland's Gatton campus. But not all residents favoured removal of the deer. Some traps were vandalised and an attempt to cull the deer by shooting was prevented by individuals walking onto the University grounds to block the operation.

It is estimated that there are 80–120 rusa in Pinjarra Hills and surrounding areas, plus an unknown number of red deer. Subsequent enquiries identified a further population of fallow deer at nearby Pullenvale. Brisbane City Council would like to eradicate these deer as many ratepayers object to their presence and they already pose a significant problem. But the Council must also contend with opposition from those who see control measures as cruel or who see the deer as enhancing the environment. In this situation, non-lethal control might appease some objectors. However, it is not likely to be effective in the long run. Brisbane City Council believes it would be in a stronger position to act if the deer were declared a pest under state legislation.

(RIDGE 2003). Rusa deer are known to have swum to the Australian mainland from the Torres Strait islands (Harrison 1998). Other rusa have swum from Papua New Guinea to the northern Torres Strait islands of Saibai and Boigu (Wilson *et al* 1992).

The Torres Strait rusa have attracted less attention from recreational hunters than other Queensland wild deer herds. There are a number of reasons for this including difficulty of access and the poor quality of trophies due to inbreeding. The Torres Strait islanders have also discouraged access, regarding the deer as an island resource. Some deer have been trapped to supply the farmed deer trade, but for the most part the harvest from the original herd is limited to those taken by the islanders for venison. As a result, rusa numbers on some islands are high and the deer (along with pigs and goats) have caused significant environmental degradation.

Because rusa are a tropical species, they are suited to farming over large areas of coastal Queensland. Javan rusa are favoured, being bigger bodied and, if velvet is harvested, carrying heavier antlers. The main source of Javan rusa has been the Royal National Park herd in New South Wales. These have been crossed with Moluccan rusa from the Torres Strait to obtain hybrid vigour in breeding programs. The Javan rusa is also favoured as a trophy by recreational hunters because of its heavier antlers.

While Moriarty (2004) does not identify any rusa populations originating from deer farm escapes, the recent spread of rusa in Queensland has certainly been assisted by the availability of farmed deer. Moriarty identifies six populations established by translocations, some in areas where rusa are known to have been farmed. Three of these are in coastal areas between Townsville and Rockhampton, and three in southern Queensland. A long-established but little known population is located near Stanthorpe.

The original Torres Strait population is among the largest of Queensland's wild rusa herds. The population is estimated to number at least 500 animals but may be substantially higher. Moriarty (2004) estimates that the Rockhampton population and one of the southern Queensland populations number between 100 and 500 animals. The remaining populations are estimated to number fewer than 100 animals although there are anecdotal reports of 600 rusa being released into a flood plain environment in the Gulf. Given the suitability of the environment, observed reproduction rates suggest that such a herd could number 3,000 within five years.

Bioclimatic data indicates that much of coastal Queensland and adjacent areas offer suitable rusa habitat. There would be cause for concern if new rusa populations are in the process of becoming established. Many of these areas are environments of high conservation value and some are already World Heritage listed.

4.2.4 Fallow deer

Fallow deer were brought to Queensland at an early date, the first shipment of six animals arriving in Queensland from Tasmania in 1865. The Queensland Acclimatisation Society held the deer in Brisbane before releasing them at Westbrook and Warwick on the Darling Downs between 1870 and 1872. Fallow deer are no longer to be found in the Westbrook area, which is mostly cleared agricultural land. However, deer from this release can still be found in areas east of Warwick.

A further release of fallow deer occurred at Pikedale, south-west of Warwick, in 1890. The descendants of these animals now constitute the major wild fallow deer herd in Queensland. Harrison (1998) estimated the population to number 'in the hundreds'. RIDGE (2003) estimates the population at about 2 800 and this figure is probably closer to the mark. This herd is broadly contiguous with larger numbers of fallow deer on the New England Tableland in New South Wales.

The Pikedale fallow deer are located mainly to the west of the grape and fruit growing areas around Stanthorpe where they have sometimes been a pest in orchards during drought (*Stanthorpe Border Post* 2002). The deer also appear to have dispersed more widely following major fires in their home range in 2001 and 2002 (M. Ridge [Inspector, Darling Downs-Moreton Rabbit Board] 2004, pers. comm., 8 October). Sightings of individual deer and small groups of fallow on grazing holdings to the south and west of Warwick have increased in recent years.

In addition to the acclimatisation society herd, Moriarty identifies five other fallow populations in Queensland: three originating from deer farm escapes (two in southern Queensland and one near Rockhampton) and two from translocations (one in southern Queensland and one in the Wide Bay area. With the exception of the Pikedale herd, all are estimated to number fewer than 100 animals.

Bioclimatic data suggests that fallow deer in southern Queensland are close to the northern limit of their suitable habitat in Australia. The failure of the original acclimatisation society herd to disperse far beyond the original release sites tends to confirm this. Recent populations resulting from deer farm escapes or translocations in northern parts of the state may not survive in the long term. But the species could expand its range in southern border areas if translocations continue.

4.2.5 Other deer species

Two of the acclimatised species of deer found in Australia—sambar (*Cercus unicolor*) and hog deer (*Axis porcinus*)—are not known to be established as wild populations in Queensland. However, anecdotal reports indicate that releases may have occurred.

Bioclimatic data suggests that broad areas of northern and central Queensland, from tropical rainforest to inland savannahs, could provide suitable habitat for both species.

'Sambar' is the Hindi word for deer. The species is common in tropical and sub-tropical habitats over a wide area from southern India up to Nepal and throughout the states of South-East Asia. It is also found on the islands of Sri Lanka, Indonesia and the Philippines.

Sambar are the largest deer found in Australia. Stags stand up to 127 cm at the shoulder and weigh around 225 kg (Bentley 1998). Colouration is dark, varying from grey and chocolate brown to almost black. Sambar are placed in the same subgenus (Rusa) as rusa deer. Although larger, they are somewhat similar to rusa, with coarse hair and similar antler conformation.

Sambar are considered by many to be the 'top' trophy species for deer hunters in Australia. On the other hand, because they are a solitary species, and not amenable to handling as herd animals, they have not been farmed to any great extent.

The initial release of sambar took place in Victoria in 1863. The animals released originated from Sri Lanka. Later releases of sambar were animals originating from India and the Malay Peninsula. The Australian population is therefore a genetic mix of a number of sambar subspecies.

Moriarty (2004) identifies the major sambar population centred on the initial release sites in Victoria and adjacent mountain areas of New South Wales. Other small populations in southern New South Wales and south-eastern South Australia are identified as originating from deer farm escapes and translocations. In addition, since their release sambar have been progressively colonising suitable habitat northward along the Great Dividing Range in what Harrison (1998) describes as a slow moving 'wave' pattern. High numbers of younger deer at the front of the wave breed up as suitable habitat is colonised, and subsequent generations continue the expansion as each new habitat niche is filled. Harrison notes a fall off in population density behind the wave as preferred browse is reduced. This highlights environmental concerns.

Sambar is a tropical and subtropical species and, while they have prospered to some degree in the southern mountain regions, they could flourish if released into the tropical and sub-tropical environments of Queensland. Harrison (1998) identifies low population densities, solitary habitats and adaptability as the secrets to the sambar's success. A breeding population may become established before their presence is widely noted.

Hog deer (also known as Para) originally ranged over a large part of the Indian subcontinent and adjacent areas. The species was found as far west as Pakistan's

Indus Valley. It is also found in Sri Lanka, Burma, Thailand and Indo-China. The term 'hog deer' is derived from the animal's habit of running through the forest with its head held low, ducking under obstacles in the manner of a wild pig rather than leaping over them like most deer (Huffman, undated).

Hog deer are small animals with a maximum height of about 75 cm at the shoulder and weighing up to 50 kg. Colouration ranges from a uniform dark brown during winter to a rich reddish-brown in summer. In some individuals light coloured spots may be visible along the sides and on either side of the dark dorsal stripe. Stags bear antlers up to 60 cm in length. These are normally three tined but extra points are not uncommon. Hog deer live as a solitary species but may congregate on feeding grounds.

Hog deer were first liberated in Victoria in 1865. The species has become established in several locations around coastal south and east Gippsland. Hunting groups cooperating with the Victorian Government, as well as some private organisations, have undertaken programs to maintain suitable habitat for hog deer, primarily to ensure the species availability for hunting. This has probably aided the species survival.

Because international hunters have found it almost impossible to gain access to hog deer in Asia, the Australian hog deer population has attracted world-wide interest. As well as being available by ballot for free-range hunting in Victoria, hog deer are also accessible in limited numbers on some Australian game ranches. The species is not commercially farmed to any great extent, but animals may be bred under captive conditions for sale to game ranches.

Unlike sambar, there is no indication that hog deer could expand beyond their traditional range in Victoria without assistance. But Moriarty (2004) has identified eight recent populations established in Victoria, New South Wales and South Australia, mainly as the result of translocations. Like sambar, hog deer could also be expected to flourish in more suitable tropical and sub-tropical environments in Queensland. Anecdotal reports from the hunting community suggest that hog deer may have been released in Queensland in recent years, possibly in wetland areas around the Sunshine Coast.

Many deer species belonging to the genus Cervus also display some ability to hybridise, particularly with other deer species which may be farmed in Queensland.

Wapiti (or North American elk) (*C. elaphus canadensis*) is classed as a sub-species of red deer. Wapiti and red deer will freely interbreed and all offspring are fertile. Sambar (*C. unicolor*) and rusa (*C. timorensisr*) are different species but will interbreed and offspring are fertile. Red deer will also join with rusa deer hinds and while all male

offspring are thought to be infertile, the female offspring are fertile. Red deer can also successfully join with sika deer (*Cervus nippon*), as can wapiti (Tuckwell 1998).

There are anecdotal reports from the hunting community of sika deer or sika hybrids being released in Queensland. Again, this would be a concern. Sika deer have displaced red deer—or swamped the red deer gene pool—in many parts of New Zealand. Briden (K. Briden 2004, pers. comm., 9 December) reports that sika are cunning enough to avoid hunters and can maintain high densities even with heavy hunting pressure. Unlike the other deer species considered in this review, sika are already a class 1 pest in Queensland.

Hybridisation is often incorporated into farmed deer programs to obtain faster growing stock. But such activities can also serve to increase the adaptability of animals in new environments. RIDGE (2003) identifies a number of new releases of deer in Queensland including Javan rusa, Moluccan rusa, and sambar (plus hybrids of all three species), as well as red deer/wapiti hybrids. The presence of these new genetic mixes compounds the possible environmental problems posed by new deer populations.

4.3 Implications for the management of deer

There is broad correlation between data on the presence of deer in Queensland collected by the Department of Natural Resources and Mines 2004 Annual Pest Assessment, the survey results published by Moriarty (2004), and information provided by RIDGE (2003). But there are also significant gaps in the various data. For example, RIDGE (and other anecdotal sources) identifies sambar as being released in Queensland but Moriarty does not. Moriarty identifies red deer in the Roma-Injune-Mitchell area of Queensland and this is confirmed by Geoff Jones, President (Queensland) Sporting Shooters Association of Australia and Tom Garrett, (T. Garrett 2004, pers. comm., 19 November; G. Jones 2004, pers. comm., 30 November)). However, the 2004 Annual Pest Assessment did not detect these populations.

Discrepancies are to be expected when new populations of deer are being established rapidly by translocation. Those seeking to establish new populations are likely to translocate animals to areas where the species has a good chance of establishing itself before its presence attracts wider attention. Deer are also cryptic animals, which may be present for some time before their presence is identified. Recorded observations are unlikely to provide a complete picture. As a result, many deer species may be more widely distributed and exist in greater numbers in Queensland than is generally thought.

In addition to the spread of existing species, the introduction of new species such as sambar, sika or hog deer could have major implications for environments, which until

recently have been free of deer. The possible impact of sambar in the wet tropics or hog deer in coastal wetlands, and the implications for some native species in those areas, gives cause for concern. The status quo could also be disturbed by the introduction of new genetic material if the effect was to increase the adaptability of deer species in Queensland.

All of these factors could have significant consequences for natural environments if the spread of deer continues unchecked.

5. Estimates of current and potential impacts

5.1 Economic issues— impact on primary production

5.1.1 Benefits

Deer may offer benefits to landholders, whether they are raised as livestock or exploited in alternative ways. Within the range of deer-based activity, there is also some gradation between farmed deer, deer restrained by fences but not otherwise farmed, and truly wild deer. The distinctions may not always be clear, as the various ways in which benefit can be extracted demonstrate:

Deer farming

Deer farming is a relatively small industry in Australia. Gross value of production (based on exports which account for 90% of output) is highly variable but in recent years has been between about $5 million and $9 million at the farm gate (RIRDC 2004). The Commonwealth Department of Agriculture, Fisheries and Forestry identifies between 50 and 80 Australian establishments engaged in deer farming. This is consistent with membership of the Deer Industry Association of Australia (DIAA), which lists 75 members across Australia, including nine in Queensland (DIAA 2005). Despite its small size, deer farming has been assessed as a sound industry with substantial prospects for growth. The industry has received targeted government funding for research and development (RIRDC 2000) and Australian deer products enjoy good access to international markets, being comparatively disease free. Austrade (2004) identifies growing export markets for Australian wild game meats in Europe, the United States, and several Asian and Pacific rim states. Income may be derived from venison, velvet, other deer by-products, and the sale of livestock. The main problem facing the export-dependent deer industry is the periodic fluctuations in international demand and price. Venison prices averaged around $4.20 per kg hot carcass weight in 2001-02, before falling to just over $2.10 in 2003-03. Prices received for velvet sank to $22.50

per kg in 1997 but recovered to peak at $100 per kg in 1999 (RIRDC 2000; Tuckwell 2003; Tuckwell 2004).

The returns from deer farming have been assessed at times as exceeding those from cattle or sheep (Standing Committee on Agriculture 1980). It has also been suggested that a combination of cattle and deer in some environments can provide better returns than from running cattle alone (RIDGE 2003). But, as the figures on venison and velvet demonstrate, financial returns can fluctuate considerably. Other livestock industries are subject to similar fluctuations in profitability and much depends on which product is enjoying high prices at the time. Nevertheless, the deer industry remains optimistic about expanding sales of deer by-products (such as tails, sinews and pizzles), which are used in some traditional Asian medicines (Tuckwell 2001). Tuckwell suggests that this market could be worth up to $60 million if Asian tourists visiting Australia purchased significant quantities of product. In the absence of such growth, the expensive set-up costs and fluctuating returns from deer farming are likely to limit new entrants to the industry and its attractiveness as a diversification strategy. Deer farming is therefore likely to remain a minor industry in Queensland for the foreseeable future.

Deer-based tourism

Tourism based around, or including deer, is a strategy that may allow deer farmers to benefit in ways other than from animal production. Deer-based tourism offers the tourist up-close encounters with deer and may provide an opportunity to raise the profile of the deer product market with visitors. A number of Queensland deer farms offer tourism experiences in conjunction with production activities. Areas of high tourist activity are more likely to make investment in deer-based tourism a viable option for the farmer. Two deer farms in southeast Queensland advertise as tourist attractions. Other tourism operations (such as farm-stays) may offer encounters with deer as part of their package. Several farm-stay operations advertised in Queensland refer to opportunities to observe deer. Deer on those holdings may or may not be kept behind appropriate fences depending on whether the enterprise is oriented towards farm or wildlife experiences.

Wild deer harvesting and trapping

Wild deer harvesting and trapping are activities from which landholders may derive a benefit from deer without the infrastructure costs of deer farming. According to Tracy Jackson (Tusker Australia Game Chiller), the commercial harvest of Chital in the Charters Towers area is about 1000 animals per year. Jackson believes that the harvest could be expanded (T. Jackson 2005 pers. comm., 17 January). The current harvest of 1000 animals at one dollar per kg would inject about $25 thousand into the local economy. Wild deer have also been harvested around Stanthorpe. However, wild

deer harvesting is not without some costs. For the wild venison trade, vehicle racks for handling carcasses need to be set up differently to racks for macropods or wild boar (T. Garrett, 2004, pers. comm., 19 November). Trapping is also losing its appeal. With substantial numbers of farmed deer now available, there is less demand for deer trapping to boost farm breeding stock. There is also increased concern that captured deer may be supplied for release into deer-free areas.

Recreational deer hunting

Landholders with deer on their land may sell hunting rights to recreational hunters. In some cases trophy fees may be charged for animals taken. Such initiatives range from simply providing access to the land on which wild deer may be found, up to full safari hunting services providing guided access either to free-ranging wild deer or, more frequently, to deer confined in large fenced paddocks. Free-range hunting access is usually sold as an adjunct to other primary production activities and would generally be described as 'fair chase' hunting. The recreational hunter who pays for access may hold no expectation other than that he or she has a chance of locating a suitable trophy if the right skills are applied. In contrast, where deer are held in large fenced areas, the service is generally identified as 'safari hunting'. The client engages the services of a safari hunting operation with the expectation of a successful hunt. Such operations cloud the distinction between farmed and wild deer as many safari hunting operations keep their animals behind fences and buy farmed deer to stock their operations. Mark Reinbott, Queensland President, Deer Industry Association of Australia, confirms that supplying deer to safari hunting operations is a significant source of income for some deer farmers, particularly when venison prices are low (M. Reinbott 2004, pers. comm.19 November). In Queensland in early 2005, safari hunting operations or individuals establishing their own herds could expect to pay $50 to $100 for red deer hinds and $120 for spikers. Rusa hinds were available for $55, with the price of stags negotiable.

A review of Australian hunting magazines identified advertisements by three deer hunting providers in Queensland. Other deer hunting guides advertising on the internet also indicated the availability of hunting opportunities in Queensland. Typical costs were just under $3,000 for a four or five day hunt for chital or red deer, including the trophy fee. Trophy fees are generally about $1,500 per stag. Some hunt providers charge more for 'hard to get' or exceptional trophies. These are usually safari hunting operations where the animals are fenced in, the quality of individual trophies is known in advance, and the operator is in a position to guarantee the outcome.

The RIDGE group in Queensland caters more for the 'fair chase' hunter. Membership of RIDGE ($50) is mandatory and hunting opportunities are balloted ($20 fee). A five-day hunt costs $500 (plus GST) plus a $500 trophy fee or $100 cull fee. The Australian

Deer Association (ADA) similarly arranges hunting access for ADA members. RIDGE and the ADA manage deer hunting access for landholdings totaling over 420 000 hectares in southeast Queensland. Landholders receive a proportion of the fees charged.

The difference in trophy fees between safari hunting operations and organisations such as RIDGE is that many safari hunting operations need to make a considerable investment in immature stags and grow them out over four or five years before suitable trophies can be identified. Consequently, a large number of animals need to be maintained to service the operation.

Safari hunting has been suggested as having development potential in Australia (Dryden and Craig-Smith 2004). But the New Zealand experience suggests that new populations of feral animals tend to appear in areas near safari park operations (K. Briden 2004 pers. comm. 9 December).

Overall, the benefit of deer to landholders is determined by the available returns, either from deer farming and associated activities, or benefits derived from wild deer, adjusted for the investment needed to achieve those returns. The value of the benefit will be determined by the returns achievable from deer in comparison with alternative uses to which the land and financial resources may be put. But the benefits also need to be considered in light of other costs that the operation may impose.

5.1.2 Costs

Deer may impose substantial costs on primary producers. The production costs of deer-based industries are not the issue here. Rather, it is the costs that wild deer may impose on agricultural production or the production environment.

Wild deer have been reported to cause damage to a wide variety of agricultural crops, pastures and forestry plantations. Their impact on rural enterprises includes damage to fences, competition for feed, spreading of weeds, fouling of water holes and harassment of stock during the rut (Glover 2000; Moriarty 2004). In south-east Queensland, damage to forestry seedlings, agricultural crops, commercial flower crops and orchards has been observed. Grazing species such as red deer are also direct competitors for cattle. Nelle (undated) points out that deer will normally choose the highest quality plants that grow in a pasture because they require a diet twice as high in protein content and with significantly higher quantities of total digestible matter than cattle. On the other hand, cattle are equipped to use a greater range of feed, including lower quality feed, and this may mask the degree of competition to some degree. Competition with livestock combined with the need for expensive deer fencing to

exclude deer from food sources means that it can be costly for a primary producer to manage wild deer.

Parasites and diseases

Deer also carry many of the same parasites and are susceptible to the same diseases as other ungulates. The diseases of major concern are listed in Table 1. These will each be discussed briefly to outline the extent of the risk.

With endemic diseases and parasites, the main concern is the cost in lost production that may be incurred if deer transmit a disease or parasite to domestic stock.

Table 1 List of endemic and exotic parasites and diseases carried by deer

Endemic	**Exotic**
Cattle tick (*Boophilus microplus*)	Screw-worm fly (*Chrysomyia bezziana*)
Leptospirosis (*Leptospira spp.*)	Surra (*Trypanosoma evansi*)
Johne's disease (*Mycobacterium avium paratuberculosis)*	Brucellosis (*Brucella abortus*)
Ovine Johne's disease (OJD) Bovine Johne's disease (BJD)	Bovine tuberculosis (*Mycobacterium bovis*)
Yersinia (*Yersinia pseudotuberculosis*)	Tissue worm (*Elaphostrongylus cervi*)
Malignant catarrhal fever (MCF) (*Gamma herpesvirinae*)	Louping ill
	Rinderpest
	Foot and mouth disease (FMD)
	Bluetongue
	Vesicular stomatitis
	Rabies
	Chronic wasting disease (CWD)

Cattle tick

The potential for wild deer in Queensland to spread cattle tick (*Boophilus microplus*) and associated tick-borne diseases is an issue of specific concern for cattle producers and the industry organisation, AgForce (*Brisbane Valley-Kilcoy Sun* 2003; Morley 2003; W. Banks [AgForce] 2004 pers. comm., 8 December). The CSIRO estimates that cattle tick costs the Australian beef and dairy industries at least $100 million annually (CSIRO 1994). Queensland primary producers would carry a substantial proportion of that cost.

Direct observation and published reports (Roth 1960; RIDGE 2003) confirm that red deer in southeast Queensland carry cattle ticks. However, Malcolm McLeod (Principal Policy Officer, Department of Primary Industries and Fisheries) advises that there is little technical data on deer in relation to cattle tick (M. McLeod 2004, pers. comm. 8 October). David McNab, a DPI&F stock inspector from Crows Nest, reports that adult cattle ticks taken from red deer in the cattle tick zone appear 'weak' when examined (D. McNab 2004, pers. comm., 11 October) This suggests that the deer may not be a good host and that cattle tick may not be viable if confined to red deer alone. This observation is supported by research in New Caledonia, which indicates that rusa deer are not a viable long-term host for cattle tick (Barré *et al.* 2002) and by research in the United States, which indicates that cattle tick may be eradicated using standard cattle parasite treatments without the need to eradicate wild deer (George 1996). Recent research in Queensland on red deer points to similar conclusions (RIDGE 2003). Studies on the tick carrying capacity of different deer species are needed to achieve a better understanding of the problem. But whether or not different deer species are viable long-term hosts for cattle tick, it appears that wild deer may still be able to carry the parasite into tick-free areas where ticks may be transferred to cattle. Research is required to determine the extent of the risk.

Leptospirosis

Queensland has the highest incidence of the bacterial disease leptospirosis in Australia. Simon Bewg (Manager, Emergency Response Capability, Biosecurity, DPI&F) points out that the uncontrolled translocation of wild deer risks spreading the disease to livestock (S. Bewg 2004, pers.comm., 14 October). But humans may also be at risk. In closely settled areas, the disease is likely to be transferred from deer to humans through domestic animals such as dogs.

Johne's disease

Queensland livestock industries also face serious risk from the spread of Johne's disease. This is another bacterial disease. The major concern is Ovine Johne's Disease (OJD). Queensland and much of pastoral eastern Australia is officially considered to be a Protected Zone for OJD under the National Johne's Disease Program Standard Definitions and Rules for Sheep. The Rules control the movement of sheep from OJD areas.

Requirements for the interstate movement of deer are incorporated into the Stock Regulation 1988. The Queensland Department of Primary Industries and Fisheries note on OJD states that 'goats and deer, other than fallow deer' are susceptible to the disease. It has been detected in deer in New Zealand and Victoria. Bovine Johne's Disease (BJD) is also an issue. At least eleven red deer herds in Australia are known to be infected. In South Australia in 2001, BJD was spread to at least five sheep flocks following the escape of infected red deer (Primary Industries and Resources South

Australia 2002). The uncontrolled translocation of deer raises the risk of spreading Johne's disease.

Yersinia

Yersinia is an issue not just because of the disease itself but because the indicators of this bacterial disease closely resemble those observed in tuberculosis infections (S.Bewg 2004 pers. comm., 14 October). Fyffe (2004b) states that all deer come into contact with yersinia at some time in their lives, but the full blown disease only develops when the animals are subjected to stress. As capture and translocation are likely to create stress, the risk of a yersinia outbreak is increased with uncontrolled translocation.

Malignant catarrhal fever (MCF)

MCF in wild deer is of concern because the disease is easily transmitted to sheep. MCF is a viral disease. Fyffe (2004c) reports that MCF occurs in thirteen species of deer, although almost never in fallow deer. Of the deer species occurring in Queensland, red deer are the most susceptible. With increasing populations of deer arising from translocations, the risk of infected deer being introduced to a sheep producing area is increased. It is thought that infection can be wind borne for up to one kilometre (Fyffe 2004c). Bewg advises that MCF may show symptoms similar to Foot and Mouth Disease, which must be precluded by appropriate tests (S. Bewg 2004, pers. comm., 14 October).

The exotic parasites and diseases of importance for deer raise other concerns. These involve the risk of deer acting as a vector for the spread of disease in any outbreak, as well as the possible role of deer in introducing new diseases to Australia.

Screw-worm fly

The threat posed by screw-worm fly and the potential for the Torres Strait rusa to assist the spread of this parasite illustrates the point. The threat has long been recognised (Standing Committee on Agriculture 1980) and monitoring stations and sentinel cattle herds are maintained in northern Australia for early detection. The proximity of the screw-worm fly threat highlights the dangers posed by the establishment of new feral deer populations in the wet tropics and the Gulf. It is estimated that screw-worm fly would cost Australian livestock industries up to $500 million in lost production and control measures annually (Curran 2002; AFFA undated).

Surra

Surra is a disease spread by biting flies (S. Bewg 2004, pers. comm., 14 October). The disease occurs widely in South-East Asia. Reid *et al*. (1999) conclude that surra has probably already reached Irian Jaya as a result of livestock movements within Indonesia, but that it may not yet be endemic in Papua New Guinea. Both deer and

pigs can carry the disease and move freely across the Indonesia–Papua New Guinea border. Thus there would appear to be a significant risk of surra reaching Australia in the same way as screw-worm fly—through the Torres Strait, assisted by rusa and pigs on the Torres Strait islands and in the Gulf.

Brucellosis (*Brucella abortus*) **and bovine tuberculosis** (*Mycobacterium bovis*)
Brucellosis and bovine tuberculosis are two serious diseases of cattle once occurring in Australia but recently eradicated under the Brucellosis and Tuberculosis Eradication Campaign (BTEC). Australia was declared free of brucellosis in 1989 and free of bovine tuberculosis in 1997 after a campaign of more than twenty years at a cost of $840 million (Australian Veterinary Association 1998). The eradication of these diseases represents a significant achievement for agriculture and the response to a future outbreak would be as for any other exotic disease. Deer are highly susceptible to both brucellosis and bovine tuberculosis and would present a risk if a new outbreak occurred in a wild deer area.

Tissue worm and louping ill
Tissue worm and the tick-borne viral encephalitis louping ill are two less well-known diseases of deer. Tissue worm is a tick-borne parasite specific to deer. In Australia, red deer and wapiti are susceptible. Both are popular farmed deer species. The disease has not occurred in Australia, although it has been detected and eliminated during post-arrival quarantine of some imported deer (Geering *et al*. 1995). Louping ill is primarily a disease of sheep, but cases can occur in cattle, horses, pigs, deer and humans. It is a member of a group of viruses, which are found in the British Isles and across northern Eurasia in regions south of the tundra. Geering *et al*. (1995) note that human cases tend to occur in hunters and forestry workers. The tick, which is the vector for louping ill does not occur in Australia. However, there is a possibility that the virus could jump to a new vector if an infected animal was introduced to Australia.

Rinderpest, foot and mouth disease, bluetongue and vescicular stomatitis
Henzell *et al*. (1999), in their government-commissioned report *Wildlife and Exotic Disease Preparedness in Australia*, list rinderpest, foot and mouth disease, bluetongue and vesicular stomatitis as exotic viral diseases of major concern, which may be spread by deer and other feral herbivores. These diseases cause mortality rates ranging from high (rinderpest) to low (vesicular stomatitis). They also cause significant loss of production. The symptoms of vesicular stomatitis resemble foot and mouth disease, which must be precluded by appropriate tests. Henzell *et al*. (1999) concluded that wild deer are unlikely to be significantly involved in any exotic disease outbreak in Australia because deer are generally secretive, have little contact with domestic stock, and are rarely abundant. However, the increasing spread and rapidly rising profile of wild deer suggests that this view may need to be reviewed. There is a need for further research on the possible role of deer in spreading disease. Bewg states that the spread of wild

deer in the rougher country along the Great Dividing Range could pose a control problem in an outbreak of any of these diseases (S. Bewig 2004, pers. comm., 14 October).

Rabies

Rabies is a viral disease, which is not present in Australia but is widespread in Europe, Asia, Africa and the Americas. The risk of rabies, and the potential for a variety of wildlife and feral animals, including deer, to transmit the disease, is well known. The disease is present in wild deer populations on other continents.

Chronic wasting disease (CWD)

CWD is a relatively new concern. It is a prion disease related to bovine spongiform encephalopathy (BSE) or 'mad cow disease'. CWD is currently endemic in deer populations throughout North America and research is continuing to determine its origins and the extent of the threat it poses. While there is as yet no evidence that CWD is readily transferable to other herbivores or humans, as with BSE, the disease may not appear for many years and there is no test for infection (Belay *et. al*. 2004). While Commonwealth regulations covering the importation of deer and their genetic material remain in place, CWD would appear to pose only a moderate risk to Australian farmed or wild deer herds.

Implications of farming

Currently, deer farming in Queensland generates only small returns in terms of venison and velvet production. No estimate of the returns from sales of live deer to hunting operations is available. But there is no doubt that wild deer can impose costs on primary producers through the damage they cause and that if deer or other feral animals became involved in an exotic disease outbreak, they could greatly extend the time taken to achieve disease-free status. The cost of responding to a disease outbreak would probably also exceed the cost of controlling feral deer on a risk management basis (Henzell *et. al*. 1999).

Therefore, to maximise the economic benefits of wild deer and minimise costs, a risk management strategy should concentrate wild deer in areas where benefits might outweigh costs and eradicate the animals from other areas. This would require eradicating all new wild deer populations (and acting to prevent the establishment of further populations) and applying controls to manage populations in the historically established wild deer areas (the feral areas defined under the repealed Deer Farming Act). It is in these areas that the capacity to extract economic benefit from wild deer is concentrated. Management of deer within these areas should be conducted in such a way as to minimise costs for those outside the deer areas.

Because deer farming is a relatively new industry in Australia, and because wild deer provided much of the rootstock for the deer farming industry, much of the recent literature on the utilisation of deer does not maintain a clear separation between farmed and wild deer. This is highlighted by the sale of farmed deer to stock safari hunting operations.

To limit the spread of wild deer, safeguards are needed to ensure that farmed deer are not returned to the wild. This will require a separation to ensure effective management of farmed deer (or other enclosed deer) on the one hand and wild deer on the other. This will enable issues in deer farming to be addressed on the same basis as any other primary industry and allow decisions on wild deer to be made as appropriate for their management. Given these considerations, it might seem that the eradication of wild deer would address both the costs and the potential risks associated with these populations. But the reality is that total eradication of the long-established wild deer populations in Queensland is probably not economically feasible or—for social impact considerations—desirable.

5.2 Environmental issues

Supporters of deer in Australia argue that deer have not and do not cause significant environmental damage. The Australian Deer Association's promotional brochure states that: 'after being present in Australia for 130 years, there is no evidence that deer are harming the Australian Environment'. Similarly RIDGE (2003) suggests that damage caused by red deer in Queensland state forests 'could be seen as more economic than environmental'. But observations and research in Australia and overseas indicate otherwise.

The extreme case for the environmental threat presented by wild deer is illustrated by the New Zealand experience. Like Australia, New Zealand had no deer prior to their introduction in the nineteenth century. But, unlike Australia, in the absence of other large fauna in New Zealand, it has been easier to identify damage caused by deer.

As deer numbers began to increase in New Zealand in the early twentieth century, people began to query their effect on the environment. Some experts compared New Zealand environments to those in Australia where the same plant species were subject to mammalian browsing without significant loss. On this comparison they suggested that the New Zealand environment would not be particularly susceptible to damage. But others pointed to the visible loss and destruction of understorey as evidence that deer and other feral animals (such as goats) were over-browsing food sources (Yerex 2001). Caughley (1983) and Yerex (2001) provide similar summaries of damage caused by deer in New Zealand. The evidence shows that:

- highly preferred plant species may suffer disproportionately
- the higher the deer population, the wider the range of plant species subject to browsing
- deer substantially modify the species composition of a forest by selective browsing
- once damage is done to a forest, even low deer numbers can perpetuate it.

Part of the problem in New Zealand was that there was no predator at the top of the biotic pyramid to keep deer in check. Aldo Leopold (1949), writing in the United States in the years before World War II, made the connection eloquently: 'Just as a deer herd must live in mortal fear of wolves, so a mountain must live in mortal fear of its deer'. With no natural predators, it became necessary to implement a major deer culling program in New Zealand to protect the environment (Caughley 1983).

Similar damage and environmental consequences have been observed in Australia.

On some Torres Strait islands, rusa deer, goats and feral pigs have caused visible environmental destruction. Nor is it simply an island phenomenon. In neighbouring Papua New Guinea, local people state that rusa have 'moulded the whole area', by causing change in herbaceous species and through soil compaction (Chatterton 1996). Similarly, Peterson (J. Petersen 2004, pers. comm., 15 December) reports large numbers of chital in the Charters Towers area causing significant environmental damage, with vegetation grazed to bare ground. Pest plants such as rubber vine (*Cryptostegia grandiflora*), chinee apple (*Ziziphus mauritania*) and parthenium (*Parthenium hysterophorus*) are also flourishing in areas where chital are not adequately controlled. Peterson reports that the land responds where chital can be fenced out or numbers reduced.

More detailed studies have been conducted to determine the impact of rusa in Royal National Park in New South Wales. Research has identified damage caused by overgrazing, browsing, trampling, ring-barking, antler rubbing, dispersal of weeds (such as Senegal tea (*Gymnocoronis spilanthoides*) and ludwigia (*Ludwigia peruviana*)), creation of trails, concentration of nutrients, exposing soils to erosion/accelerating erosion, and the subsequent degradation of water quality in creek and river systems (Clarke, *et al.* 2000). In addition, a significantly lower diversity and abundance of plant species have been noted in environments (in and around the park) at high deer density locations than in those of low deer densities (Moriarty *et al.* 2001).

The extent of dietary overlap between wild deer and macropods requires more detailed research. A study by Hamilton (1981) of rusa deer in Royal National Park showed a 13 per cent overlap in diet with the swamp wallaby (*Wallabia bicolour*) in summer and a 54 per cent dietary overlap in winter. Moriarty *et al.* (2001) estimated an average 15 per cent annual dietary overlap with the same species. The Scientific Committee of the New South Wales National Parks and Wildlife Service has considered such evidence sufficient to make a preliminary determination supporting a proposal to list herbivory and environmental degradation caused by feral deer as a key threatening process impacting on vulnerable or endangered species, populations or ecological communities (Adam 2004).

The four species of feral deer in Queensland all feed on a combination of shrub, understorey and grass species. The reports above indicate that two of these species have caused significant environmental damage where deer numbers are high. But all could be expected to have some impact on their environments. In the 100 years or more that deer have roamed private and public landholdings in Queensland there has been more than enough time for animals, which are selective feeders, to influence the mix of both plant and animal species. However, without comparative studies it is not possible to assess the environmental changes that may have occurred.

On the positive side, it has been noted that deer will browse some pest plants, including lantana (*Lantana camara*) and prickly acacia (*Acacia nilotica* ssp. *indica*). Nevertheless, it is unlikely that the degree of control achieved would justify the cost of fencing to contain deer for a control program.

Studies in New Zealand suggest that the pattern of environmental damage and the deer population both stabilise after about 40 years (Caughley 1983). The supporters of deer may therefore be justified in their claims that the established deer populations in Queensland are causing no further environmental damage. But the same studies provide sound arguments for not allowing new deer populations to become established elsewhere in Queensland, as is currently occurring.

The potential for significant levels of environmental damage is perhaps best illustrated by the threat that new deer species may pose to vulnerable Queensland ecological communities. Perhaps the greatest threat arises from the possibility that sambar and hog deer might be released in areas such as the wet tropics. These species could have adverse effects on sensitive north Queensland environments—including World Heritage areas—and could increase pressure on endangered indigenous wildlife such as the southern cassowary.

Until comparatively recently it could be fairly said, as Harrison (1998) points out, that deer have had such a low profile that ‘many Australians don’t even know of their

presence and most have never seen a wild deer'. However, the situation is changing. Rapidly growing numbers of deer combined with many new and highly dispersed populations underpin Moriarty's (2004) assessment that 'Wild deer in Australia have moved from a minor component of the Australian biota to one that is now widespread'.

The supporters of deer (for example, Harrison 1998; RIDGE 2003) argue that, although they are an introduced species, deer are now a part of the Australian environment and deer management should be an integral part of wildlife management. The same argument is rarely used for other introduced game animals—the rabbit, hare and fox. The impacts of the rabbit and fox have been studied in much more detail and they are known to be highly destructive across a wide range of ecological communities. But the impact of wild deer across Australia is yet to be quantified. Consequently there is insufficient data to properly inform judgements, which may otherwise be coloured by the symbolism and romanticism attached to deer. Research is needed into the impact of deer on Queensland environments.

5.3 Social issues—benefits and costs

The majority of Queenslanders live in urban areas. Most have little direct experience of non-urban environments, except in areas generally accessible to tourists, and have little regular contact with wildlife or rural industry. Nevertheless, many of these people hold an opinion on the status of deer in Queensland's natural environments. Even those who hold no opinion may still form a view if the management and control of wild deer becomes a topic of public debate. For this reason, it is essential that information is available, which will assist people to form a balanced view of the relationships between wild deer, the environment, primary producers, deer hunters and other interested parties.

Those who hold an opinion on wild deer can be placed in three categories according to their attitudes:

1. **Those who reject the notion that exotic, introduced animals have any place in Queensland's natural environment**
   For this group, wild deer represent only a cost: a theoretical cost because they diminish the natural environment through competition with native species and land degradation, and a real cost if eradication is undertaken. This group would probably support the eradication of wild deer, although the cost of eradication may be an issue.

2. **Those who place an aesthetic value on wild deer and see them as increasing the appeal of the natural environment**
   For this group, wild deer represent a benefit, which outweighs most costs

associated with their presence. A proportion of this group would acknowledge the need to cull wild deer in situations where they are in pest proportions. Others would oppose any eradication campaign, although they may support alternative pest control measures such as fertility control (for example, Oljes 2000).

3. **Recreational deer hunters**
   For this group, wild deer provide both tangible and intangible social benefits: tangible benefits in the amounts spent by deer hunters pursuing their recreation, and intangible benefits in the positive experience this gives the hunter through interaction with the environment and the flow-on to associated interests such as conservation. This group would probably support the control of wild deer, but only in a context that allows ongoing, sustainable deer hunting. Experience in other states shows that most hunters are prepared to pay for access to hunt deer, particularly if fees are returned to the management of game or conservation activities. Hunting licence fees have been applied in this way in Victoria for many years (Harrison 1998). A similar arrangement is being implemented in New South Wales under that state's Game Council. In Queensland, private arrangements have been established between some landholders and deer hunting groups to provide financial and in-kind payments in return for hunting access (RIDGE 2003).

Social benefits—recreational hunting

Some idea of the number of people who value the presence of deer in Queensland may be ascertained from the size of the recreational hunting community. Cause (1995) estimated that there were 1400 deer hunters in Queensland in 1990. However, many of those would not have been members of any deer hunting organisation. The Queensland branch of the Australian Deer Association has about 250 members (A. Fischle [Queensland State President, Australian Deer Association] 2004, pers. comm., 23 October). The group Research into Deer Genetics and Environment (RIDGE) has a similar number. Some individuals are members of both organisations. A better indication of the level of involvement is provided by Jones who advises that there about 40 000 members of the Sporting Shooters Association of Australia in the state, ninety per cent of whom would be involved in some form of hunting (G. Jones 2004, pers.comm., 30 November). Based on these figures there are likely to be several thousand Queenslanders who would claim some interest in recreational deer hunting and who would probably support the management of wild deer as a game animal.
The amount expended by hunters in the pursuit of deer is a tangible benefit that flows back to society generally. Over the years, recreational hunters have attempted to quantify the amounts spent. Because it usually requires a significant investment in time to locate and take a trophy animal under fair chase conditions, this may be a

considerable sum. Cause (1995) reports on a 1990 survey, which estimated that some 17 500 deer hunters Australia-wide accounted for an annual expenditure of more than $58 million on hunting equipment and associated costs. This would equate to about $85 million at 2004 prices, without taking account of any increase in the number of deer hunters. Cause further reported that deer hunters each took an average of 0.87 deer per year. Based on these figures (17 500 hunters spending $85 million and taking 0.87 deer each per year), the average cost of taking a deer would be about $5500. The figure is not unrealistic. Cause reports that deer hunters make an average of about 10 hunting trips per year or around 12 trips to take a deer. This equates to about $460 per trip at 2004 prices.

RIDGE (2003) estimates a total expenditure of $2 million by 500 deer hunters under its program since 1996. If each of those hunters took one deer, this would equate to an average of $4000 to take a deer. No direct comparison can be made with Cause's data as the RIDGE information is not strictly comparable. However, both sets of figures suggest that deer hunters are prepared to spend considerable sums of money on their recreation, not all of which relates to the actual taking of a deer.

Taking the RIDGE (2003) data a step further, the RIDGE estimate of a sustainable harvest of around 1350 red deer in southeast Queensland suggests a potential expenditure by hunters in excess of $5 million annually. Expenditure on hunting other deer species in the state would increase this figure.

Recreational hunting also confers other social benefits. Hunting organisations make the point that recreational hunting relies upon conserving wildlife and that hunters have a long history of conserving and restoring wildlife habitat through their efforts, funds and lobbying power (Peake 1999). The Sporting Shooters Association of Australia cooperates with the national parks service in South Australia each year to provide feral pest control in sensitive areas of the Flinders Ranges (Sporting Shooters Association of Australia 1998). The same organisation is assisting with the re-establishment of the bridled nail-tailed wallaby on private property in Central Queensland (G. Jones 2004, pers. comm., 30 November). The Victorian Field and Game Association is involved in the restoration of wetlands (Victorian Field and Game Association undated). Government reports have acknowledged such contributions:

> Hunting has considerable potential to assist with conservation objectives particularly for areas of land which are perceived to have little other economic value (such as swamps and wetlands)

(Senate Rural and Regional Affairs and Transport References Committee 1998).

Social costs

Set against the assumed benefits of recreational hunting are the social costs imposed by the existence of wild deer. In recent years, it has become more common for wild deer to be involved in motor vehicle accidents in built up areas and on major highways (Glover 2000; Giles 2004). Exact figures are not available as insurance companies record all accidents involving wildlife in a single category. Nevertheless, even a single fatality or severe injury may impose a social cost which exceeds the imputed $5 million social benefit of recreational hunting expenditure. There are additional social costs in damage caused by deer browsing in parks and gardens, and the potential threat of rutting stags, particularly if deer in urban areas become habituated to people. There may also be social distress caused by the sight of killed or wounded deer on suburban streets.

Other social costs accrue from the diseases that deer may transmit to people living in areas in which wild deer are found. Wild deer may be a source of zoonoses such as leptospirosis and tick-borne diseases. Infection is more likely in those coming into close contact with wild deer, such as hunters and agricultural workers. However, the potential for disease transmission becomes an increasing public health issue as wild deer intrude more into outer urban areas.

5.4 Net cost or benefit to the state

Harrison (1998) argues that if deer have little or no adverse effect on the environment and can be managed to produce a benefit, then it would be absurd to eradicate them because they are not natives. Further research is required to ascertain the actual extent of environmental damage caused by deer. But, even then, it is only in specific and identifiable areas that any benefit might be realised. The overall picture in Queensland points to the costs and potential costs of deer outweighing benefits, and to a potential pest problem.

The economic activities involving deer are important to the individuals engaged in them and it is desirable that deer farming in particular be permitted to grow and achieve its potential. Recreational deer hunting also offers benefits to society in the form of the expenditures of deer hunters as well as their commitment to and private investment in feral animal control and other environmental programs. But the interests of deer farmers and recreational hunters must be balanced against the need to minimise the environmental costs imposed by wild deer.

To maximise the potential benefits and minimise the costs imposed by deer, it is first necessary to separate the interests of the deer farming industry from the management

of wild deer. The key to minimising the costs then lies in the management of wild deer populations. For this, the goodwill of interested parties is required.

Many recreational hunters would lean more towards the management of wild deer as game than their declaration as pests. Their preference would be for the availability of deer in areas where hunting was possible and permitted. This is compatible with the situation where deer are established in altered environments and their numbers can be maintained to ensure stability in terms of their impact on the biosphere. At the same time, the recreational hunting community would probably not be opposed to the removal of deer from areas where they pose the greatest social risk or environmental threat. Other members of society who have no interest in hunting may also have no issue with wild deer continuing to exist away from those urban areas where they are most likely to pose a social risk.

A compromise position of allowing deer to be managed as game in those areas where they were established historically and seeking cooperation for the eradication of new populations of feral deer, would probably accord deer a social value acceptable to the majority of recreational hunters, satisfy many of those who value deer for other reasons, and minimise both the social costs of the current deer distribution and the cost of deer control.

6. Management of deer in Queensland

In devising a strategy for the management of deer in Queensland, it is necessary to do two things:

- Clearly differentiate farmed deer (or other enclosed deer) from wild deer.
- Establish the framework needed for the managemnent of wild deer.

Some legislative changes would be required to achieve these objectives.

6.1 Farmed deer and wild deer

Deer farming is an established industry, which should not be severely impacted by any action taken to control or manage wild deer. However, while Australia's established wild deer herds provided most of the rootstock for Australian deer farming, the evidence suggests that farmed deer in turn—whether by escape or deliberate translocation—have been the source of many of Australia's new wild deer populations (Moriarty 2004).

To protect the interests of the deer farming industry and address the problems with wild deer, it is first necessary to distinguish farmed deer from wild deer. This requires a definition of farmed deer, which distinguishes the animals from wild deer and a regime for the management of farmed deer, (or other enclosed deer) which precludes them from passing back into the wild.

Deer are included in the definition of stock under the *Stock Act 1915*. Similarly, the Nature Conservation Regulation 1994 defines deer as a domestic animal. The classification 'stock' or 'domestic animal' can only apply to those species of deer that are not declared in Queensland. All other deer are class 1 declared pests under the *Land Protection (Pest and Stock Route Management) Act 2002* and the Land Protection (Pest and Stock Route Management) Regulation 2003 and can only be kept under permit.

The Land Protection (Pest and Stock Route Management) Regulation 2003 lists eight species of deer that are not class 1 declared pests and which may therefore be held as stock or domestic animals. These are the six species of deer historically established in the wild in Australia—chital, hog deer, red deer, rusa, sambar and fallow deer—plus wapiti/elk and white-tailed deer. The current exclusion of these species from declaration as class 1 pests reflects their status as currently or potentially farmed and their low pest potential ascribed by earlier assessments. The definitions under the Act do not distinguish between wild deer and deer kept in enclosures. But the emerging problems with translocation and the spread of wild deer means that the pest potential of these species and their classification under the Act needs to be re-assessed.

Commercial deer farmers select for temperament and productivity, attributes that over time may lead to strains of deer that are identifiable from their wild rootstock. Until that time comes, however, the ability of deer to pass easily from wild to farmed state and back to the wild (as evidenced by the sale of farmed deer to stock safari hunting enterprises) highlights the fact that a farmed deer is distinguished primarily by:

- the deer fence that prevents the deer from escaping
- the identification carried by the farmed deer that indicates ownership of that animal.

If wild deer are to be managed, the first step must be to prevent more deer from entering the wild. Identification of farmed deer is critical to ensuring that wild deer can be managed and that farmed deer, which escape or are released to the wild, can be traced to their origins. These objectives may be achieved by defining a farmed deer as

a deer that is kept in an enclosure that prevents the deer from escaping, and requiring livestock identification similar to that applying to other stock, such as cattle and horses.

Currently, the *Brands Act 1915* and Brands Regulation 1998 do not require farmed deer to be branded. However, the inclusion of farmed deer under the National Livestock Identification Scheme (NLIS) should assist in addressing this issue. The NLIS will apply to cattle from 1 July 2005. It is intended to bring deer under the NLIS at some time in the future, along with horses, sheep, goats and pigs.

Deer contained in areas operating as safari parks would need to be brought under the same or an alternative management and identification regime to minimise the risk of animals escaping into the wild from these operations. The New Zealand experience suggests that safari parks require such regulation to prevent the spread of feral animals. For risk management, safari parks in New Zealand are restricted to areas specified for deer farming or, for some other species, to locations within the feral range of those animals (Department of Conservation, New Zealand 2001).

Legislative changes would be required to introduce the definition to identify farmed (or enclosed) deer, and to bring farmed (or enclosed) deer under the NLIS at the appropriate time.

6.2 A possible framework for the management of wild deer

Defining and identifying farmed (or enclosed) deer would allow all other deer to be recognised as wild deer. The management and control of these animals needs to be commensurate with the threat that they represent, the feasibility of broad scale control, and the degree of public support for control likely to be forthcoming.

Currently there is no Queensland legislation for the management of wild deer, nor any regulation to prevent the eight species of deer, which are not class 1 declared pests, from being released into the wild. There have been calls for the declaration of deer to facilitate their management. However, experience with the *Nature Conservation Act 1992* shows that among those with an interest in the control of wild deer, there are two opposing camps with differing objectives in mind.

1. There are those who wish to see deer declared a pest and controlled or eradicated. This group includes those primary producers who see wild deer as a direct threat to their production processes and infrastructure, those concerned about damage to the environment, and local governments and members of the wider community concerned about deer causing damage in outer urban areas and being involved in road accidents.

2. There are those who wish to see deer protected. This group is split between those (including some landholders) who would like deer to be protected so that they can be managed as game for recreational hunting purposes and those who would like to see deer receive the same protection as native wildlife species, which are not hunted.

Given the current proliferation of wild deer, the weight of economic, environmental and social argument generally supports those arguing for declaration of deer as pests. However, this does not apply consistently to all areas of the state and would create some problems in policy implementation. Declaration would place the onus on landholders to take appropriate control action. Not all landholders would welcome or support such a move. Nor would declaration lead to the automatic commitment of public funds to a control program. Nevertheless, declaration is likely to be required if the proliferation of wild deer is to be addressed and a framework must be established within which declaration can be managed.

The major threat to Queensland's natural environments is from the release and establishment of deer species not already present in the state—particularly sambar and hog deer. There are sound environmental arguments for acting to prevent the introduction of these species as well as any other deer species not yet established in Queensland. In the interests of protecting the environment, all deer (members of the family Cervidae) could be declared class 1 pests, with the exception of the four species of deer historically established in Queensland—chital, red deer, rusa and fallow deer.

Declaration as a class 1 pest would mean that the species may not be introduced to the state, or fed, supplied, kept, or released.

In the historic deer ranges, a pest declaration applied to the established deer species would conflict with the objectives of landholders who derive a portion of their income from wild deer and the interests of recreational hunters and organisations who favour the management of deer as game.

However, action to prevent the further spread of deer and eradicate new populations would be facilitated by the declaration of the four established deer species if the declaration applied only to deer of those species outside their historic deer ranges. Support from recreational deer hunters is more likely to be forthcoming if wild deer are able to be managed as game within the historic deer ranges. Support is also likely to be forthcoming from those recreational hunters who have an overriding interest in protection of the environment. These individuals would probably support the eradication of new deer populations outside the established deer ranges.

The Land Protection (Pest and Stock Route Management) Act, Section 36 (a) enables an animal or plant to be declared a pest 'for the State or a part of the State'. Under this provision, the four established deer species—chital, red deer, rusa and fallow deer—could be declared pests for part of the state only. That 'part of the State' would be all areas of the state except the historically established ranges of those deer species.

The precedent for such a declaration already exists. The geographical boundaries of the historically established ranges were defined as the 'feral areas' under the repealed Deer Farming Act. Exempting those areas from any declaration should not raise significant environmental concerns. The species are long established in those areas and, while research indicates that deer may have significant environmental impacts, the major changes would have occurred as many as one hundred years ago and the process has probably now stabilised. Due to the revenue-earning potential and cachet attached to deer, the exemption is likely to be supported by landholders and local government councils in the established deer ranges. The exemption would not impede the control of deer as pests where necessary. It would also be likely to receive broad support from recreational deer hunters if it came with some recognition of the positive values attached to their pastime and an acknowledgment of the legitimacy of property-based deer management and hunting arrangements negotiated between landholders and hunters. This would be in line with the evolving approach to managing access to game in other states.

If arrangements were implemented to ensure equitable access for those wishing to engage in recreational deer hunting, they may go some way to breaking down the tradition of illegal hunting. It is generally acknowledged that illegal hunting flourished under the restrictions of the past and the issue remains a significant concern for both hunting organisations and landholders in deer areas.

Declaring chital, red deer, rusa and fallow deer Class 2 pests for the remainder of the state would mean that those species could not be introduced, fed, kept, supplied or released outside their historically established ranges. Under the Land Protection (Pest and Stock Route Management) Act, Section 77, landholders in the remainder of the state would be required to take reasonable steps to keep their land free of these deer species.

On environmental grounds, such a declaration is likely to receive broad support. Considering that the major environmental changes brought about by deer in the established deer ranges are most likely to have occurred many years ago, properly managed wild deer are probably not the major contributors to current environmental pressures in those areas. But the fact that deer were historically established in one area provides no grounds for arguing that they should be released somewhere else regardless of their environmental impact.

Pest declaration would assist in addressing both the proliferation of wild deer and their potential to cause environmental damage.

7. Deer control strategies

There are a number of options for controlling pest animals. The Standing Committee on Agriculture (Animal Health Committee) (1992) provides information on standards for the destruction and capture of feral animals, including deer.

Options for control can be divided into lethal and non-lethal means. Non-lethal means can be further divided into temporary and long-term measures. The measures associated with each option are discussed here in terms of their particular advantages and disadvantages.

Non-lethal temporary control measures

Most of the literature on non-lethal temporary control deals with the control of white-tailed deer in suburban environments in the United States. However, the measures would seem to be broadly applicable to any situation where deer are a problem, particularly in closely settled or suburban environments.

DeNicola *et al.* (2000) identify frightening devices and repellents as short-term control measures. Frightening devices include strobe lights and gas-fuelled explosive devices. The main problem is that, over time, deer become used to such devices and their effectiveness is reduced. In closely settled areas, the devices are also likely to be as much of a nuisance to human residents as they are to the target animals. Odour-based chemical repellents may be used in suburban areas in partial alleviation of garden browsing. However, repellents are generally used for the protection of individual plants and they are not suitable for use over large areas (Williams 2001).

Non-lethal long-term control measures

Non-lethal, long-term control measures can be costly and may be limited in their practicality. An important consideration is that measures to exclude deer from certain crops or areas will simply cause a change in behaviour. The deer will shift their attention to alternative crops or move to other locations where they become a new problem.

Guard-dogs in areas that can accommodate invisible containment (for example, using electronic dog collars) have been used successfully to exclude deer (DeNicola *et al.* 2000). But such controls are expensive and suited only for limited areas.

Exclusion barriers, such as deer fencing, are expensive and not suited to individual suburban blocks.

Where deer present a risk of traffic accidents, devices that target the deer—such as roadside reflectors and whistles on vehicles—have not been effective in tests in the United States (DeNicola *et al.* 2000). Fencing roads to exclude deer is also too expensive to be a realistic option in most situations. The alternative is to use signage to alert motorists to the presence of deer and apply speed limits if necessary. Little else is available.

Perhaps most importantly, the majority of these measures attempt to control only the movement of deer and not their numbers. Capture and fertility control, on the other hand, are two measures that can be used in population control.

Fertility control has been investigated and trialled in the United States in the form of virus-borne immunocontraceptives and conventional dart-injected chemical contraceptives. Immunocontraceptives pose the risk of jumping to other ungulate species and do not appear to have been trialled in the wild. In contrast, conventional dart-injected chemical contraceptives have been used with some success to control deer numbers in closely settled areas. Experiments with dart-injected contraceptives have been conducted on rusa with a view to implementing deer control in Royal National Park in New South Wales. In that situation the object was to avoid adverse publicity. Nevertheless, there is a considerable difference between using contraception to control a native species in urban areas of the United States and using the method to control an exotic species in Australia. Although darting has appeal from a public relations perspective, only authorised officers could implement a program. It also has its limitations. The Standing Committee on Agriculture (Animal Health Committee) (1992) lists dart-administered chemical restraint as an acceptable capture method for deer, but lists neuro-muscular blockers (paralysing drugs) and electro-immobiliser darts as unacceptable. In any case, a darting strategy is not compatible with efficient eradication. Deer can just as easily be darted for capture or destruction, and destruction would probably be the preferred option for removal of new deer populations in Queensland.

Darting is only one method of capturing deer. Baited traps or traps constructed on tracks or watering points may also be used to reduce numbers or as part of an overall eradication program. The one qualification with these methods is that they are not necessarily non-lethal. Deer trapping can result in high rates of mortality as a result of accidents during capture and post-capture myopathy (Williams 2001).

Non-lethal control methods have some appeal as strategies in outer urban environments where public opinion is an issue. But trapping is an expensive technique

(Williams 2001) and, where the object is to remove deer from the environment, the question remains of how to dispose of captured deer. Release to the wild elsewhere is not an option and there is now limited demand for wild-caught deer to stock deer farms. Euthanasia is the most likely outcome if deer trapping is employed. Trapping would therefore become a lethal control measure by default.

Lethal control measures

In Queensland, where the object is likely to be to eradicate new populations of deer and ensure adequate control in other areas, lethal control measures will be required at some point.

The major lethal control measures are discussed below:

Poison

There are no poisons registered for use on deer in Queensland. Sodium fluoroacetate (1080) is a possible candidate. In Queensland, 1080 is approved for use on foxes, rabbits, pigs, dogs, dingoes, and rats. It is used in New Zealand to control a wide range of pests, including deer in some situations. The New Zealand experience suggests that 1080 is expensive when applied over large areas (Caughley 1983). However, it has been used successfully to control localised populations of deer that cannot be killed by other means. According to Fraser *et. al.* (2003), 1080 gels smeared on leaves of palatable plant species reduced high-density white-tailed deer populations on Stewart Island by over 90%, and reduced a moderate-density red deer population in the central North Island by 78%. The poison is regarded as less useful for dealing with low-density populations where food is abundant. It is also considered unlikely to achieve complete eradication (Fraser *et. al.* 2003).

In Queensland, the use of 1080 to control wild dogs has been criticised for its alleged impact on non-target species. Whether or not such criticisms are valid, canine species are particularly susceptible to 1080, requiring a dosage of only 0.1 mg per kg body weight. Deer require a much higher dosage of 0.5 mg per kg body weight. With deer being a much bigger animal as well as requiring a higher dosage rate, the risk to non-target species could only increase. Organisations such as the RSPCA are opposed to the use of 1080 (Sherley 2002) and there is likely to be general community opposition to the use of 1080 or other poisons to control deer.

Studies on other poisons for deer have not been conducted in Australia.

Trapping

Trapping may be an option for deer control in some situations and may be the most publicly acceptable method of control in closely settled areas. Euthanasia of trapped

deer may still be an issue. Further, while trapping may remove the majority of a deer population, the remaining trap-shy individuals would still need to be removed by other means. Shooting is likely to be required at some stage if complete eradication is the objective.

Helicopter shooting

At the height of the deer farming days in Queensland, many deer were captured using helicopters. Helicopter shooting was popular in the early days of venison harvesting in New Zealand (Caughley 1983) and has continued to prove effective and economical where deer are in sufficient densities and vegetation cover permits (K. Briden 2004, pers. comm., 9 December). However, most new deer populations in Queensland are at comparatively low densities and in areas of thick cover. The Standing Committee on Agriculture (Animal Health Committee) (1992) has suggested that, if animals such as deer were targeted for removal in response to an exotic disease outbreak, shooting from a helicopter would be one of the most effective means of implementing emergency control. But this would need to be weighed against the risk of disturbing and dispersing the deer population. In all other circumstances, helicopter shooting is unlikely to be an economic option for general deer control.

Ground shooting

In the United States, ground shooting is considered to deliver the best results in deer control for both program effectiveness and cost effectiveness.

Williams (2001) argues for regulated hunting as a key plank in deer control. According to Williams, regulated hunting has been historically the most effective means of controlling deer populations in North America while at the same time it has ensured the long-term security of deer species. This is supported by Caughley's (1983) observation that recreational hunting had been underestimated as a means of deer control in New Zealand. Williams (2001) argues that the system works because it relies on the motivation of individual hunters to harvest a portion of the herd at regular intervals. It also allows the harvest to be conducted without public expenditure to pay for the control. This is similar to the argument for the system of deer management proposed by the RIDGE group in Queensland. Briden confirms the usefulness of recreational hunters in managing overall deer numbers with the reservation that, where trophy hunting is the focus, recreational hunting can also disturb and disperse deer making final objectives in eradication more difficult to achieve (K Briden 2004, pers. comm., 9 December).

Williams (2001) also draws a distinction between regulated hunting to control deer populations outside urban areas and ground shooting of pest deer in closely settled areas. Williams suggests that professional shooters can be used to destroy deer in closely settled areas, but (as with trapping) the strategy requires considerable funding.

Costs vary depending on the level of control needed, the topography and various social factors. An advantage of using professional shooters is that they are under the direct control of the hiring authority. A precise contract can be arranged and standards for handling animals can be set. The effectiveness of professional shooters may be enhanced by allowing them to use spotlights and shoot at night, and to bait areas and shoot from established blinds.

Williams (2001) argues that the comparative efficiency of professional shooters versus recreational hunters is influenced by the size of the area where control is needed. Professional shooters will be most effective on small areas and can operate safely even in closely settled areas. Briden (2004, pers. comm., 9 December) supports this position. A typical method of safe shooting is to fire into the ground from blinds erected at heights of ten metres above bait stations. Issues relating to the discharge of firearms in urban areas would need to be addressed before such a program could be implemented.

Professional shooters may also be more appropriate and effective in responding to critical situations in the establishment of new deer populations (for example, to respond to a release of sambar in the wet tropics). On the other hand, recreational hunters are likely to be more effective if the area needing control is large and if they operate under a pest control plan.

In general, the cost of ground shooting is determined by the time it takes the hunter or shooter to cover ground and the time required to locate animals at low population densities. For those reasons, in areas where ground shooting is an appropriate tool for control or eradication of deer, the cost of control may be minimised by enlisting recreational hunters to assist in the implementation of programs. The major hunting organisations in Australia have hunting and conservation divisions, which address themselves to feral animal control and cooperate with both landholders and government agencies for those purposes. The members of these divisions are trained and tested to appropriate skill levels by their organisations, and take part in planned pest control activities, including the gathering of data and samples for research purposes. This enables objectives in control and eradication to be achieved efficiently, cost-effectively and humanely.

In closely settled areas, professional shooters may be preferred because they can be contracted to perform eradication under specified conditions. This addresses issues of risk and public liability.

Hunting with dogs

With species such as sambar or hog deer, which may have been released into tropical areas in Queensland, or the large numbers of rusa, which are reported to have been

liberated in the Gulf, appropriately trained dogs may be used by hunters to take deer under conditions where conventional ground shooting would be difficult. Examples of difficult conditions for locating and shooting deer include tropical rainforest and pandanus swamp, where sambar and rusa may have been released. While there are objections to the use of dogs in some situations, dogs which bring an animal to bay rather than attack would allow humane destruction of deer in circumstances which would otherwise make eradication impossible. Briden (K. Briden 2004, pers. comm., 9 December) confirms that professional ground hunting with dogs is a good way to detect and control deer at low densities in bush areas.

Biological controls

Predation by wild dogs, foxes and eagles is believed to limit deer populations in some areas. Young animals would be the main targets. There are no other biological controls that appear useful as a control agent for deer. As with immunocontraception, it is likely that any potential control organism would present an extreme risk to domestic ungulates.

The choice of strategy and means of control is usually dictated by factors such as species, population density, type of terrain, and economics. If and when wild deer are declared in Queensland, different strategies and mixes of control measures are likely to be required for different situations. In all cases, those measures will need to be implemented with consideration for how deer control is likely to be received by the general public. Consequently, given the high regard in which deer are held in some sections of the community, a communication strategy needs to be developed to educate and inform public opinion before any control strategy is implemented.

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