3. Economic and environmental impacts and values

Summary

Wild dogs have impacts on agriculture through predation of livestock. Measuring stock losses alone usually underestimates the true economic cost of wild dogs because these estimates do not include costs of dog control, the opportunity costs and other costs associated with wild dogs (for example, not grazing sheep on otherwise suitable land). However, most economic assessments have been limited to calculations of stock losses because these are the easiest and most comprehensible measures for landholders to use. Studies in Western Australia, Victoria, New South Wales and Queensland have shown that predation of sheep and cattle can threaten the economic viability of properties in some areas. Sheep are the most commonly attacked livestock, followed by cattle and goats. There is evidence of seasonal peaks in predation on livestock, possibly related to the seasonal breeding activity of wild dogs, as well as the timing of lambing and calving.

Although many wild dogs will attack or harass sheep, some individual wild dogs cause far more damage than others, sometimes maiming without killing outright. The presence of wild dogs can adversely affect the distribution and behaviour of sheep, even when dogs do not actively harass them. Wild dogs sometimes chase sheep without following through with an attack. This may lead to stress-associated behaviour such as mismothering of lambs and loss of production. Even when wild dogs kill sheep, they often leave carcasses uneaten. Individual wild dogs that kill sheep often eat natural prey such as kangaroos, indicating that killing of livestock is independent of the presence of natural prey.

Wild dogs have been in Australia long enough to become a functional part of the mammalian predator–prey relationships and fulfil an important role in the functioning of natural ecosystems. Dingoes are implicated in the extinction of Tasmanian devils and thylacines from mainland Australia. Dingoes are regarded as a native species and are subject to legislative protection in some States and Territories.

Wild dogs are implicated in the spread of hydatids which is a risk to human health and the cause of losses of production associated with hydatidosis in cattle and sheep. Wild dogs also provide a reservoir for heartworm infection and diseases such as parvovirus. Dog rabies is presently exotic to Australia, but of all Australian wildlife, wild dogs pose the greatest risk of maintaining and spreading dog rabies if it was introduced.

The dingo, often considered a native Australian mammal, has an intrinsic and aesthetic value and there is a public expectation that it will be conserved. Other wild dogs, as top order predators, may have an important, but as yet unclear, influence on the biodiversity of animal communities. They might also have an inverse density relationship with foxes and therefore be important in limiting the impact of foxes and cats on populations of small and medium-sized mammal prey.

In areas where dingoes are a major tourist attraction, they occasionally show aggressive behaviour towards people, particularly if they are often fed to encourage closer viewing.

3.1 Economic impact

The threat of predation of livestock by wild dogs has largely determined the distribution of sheep and cattle in Australia (Figure 2) (Newsome and Coman 1989). Rapid expansion of the sheep industry after the successful early 1800s ventures of the MacArthurs and Marsden into merino breeding brought the problem of predation by wild dogs to the attention of early legislators (Section 5.1.3). Sheep were under the constant supervision of shepherds (Gould 1863; Rolls 1984) who had responsibility for preventing sheep straying and preventing predation by wild dogs. The amount of fencing for the enclosure of livestock increased after the *Nicholson Land Act*

Even when livestock are not killed outright by wild dogs, economic losses may arise due to veterinary costs, decline in livestock condition and downgraded sale prices (Source: L. Corbett).

Victoria 1860 and the *Robertson Free Selection Act NSW 1861*, and the shortage of labour that accompanied the 1860s goldrushes. Consequently, the use of shepherds became less common although the threat of wild dog predation ensured that considerable investment of labour continued to be placed on wild dog control. Predation has continued until the present although there have been few attempts to quantify losses at more than the property scale.

A Western Australian example of losses caused by dingoes over an 18-day period is given in (Thomson 1984a) (Table 2). These loss figures are considered conservative as some events could have been missed and sheep were being mustered from the paddocks so not all were available to dingoes for the full period. Extrapolation of the data in Table 2 suggests an annual loss of 33% in area A and 16% in Area B. Had dingo activity continued, direct losses of this magnitude, along with those due to harassment, would have seriously threatened the viability of the enterprise (Thomson 1984a).

Predation of livestock by wild dogs continues to threaten the livelihood of some livestock producers in tableland environments of eastern New South Wales, the Australian Capital Territory and Victoria. In parts of the eastern tablelands of New South Wales, wild dogs are regarded as the major limitation to sheep production (Fennessy 1966; New England Rural Development Association (NERDA) undated c.1966; Hone et al. 1981; Schaefer 1981; Fleming and Robinson 1986; Fleming and Korn 1989). Holdings where wild dogs are a problem are mostly situated along the Northern and Southern Tablelands of New South Wales (Fleming and Korn 1989). The study by NERDA (c. 1966) also estimated the opportunity cost of sheep not being run in areas that were suitable but for the presence of wild dogs. The timing of the survey corresponded with a regional increase in pasture improvement with superphosphate. It was believed that pasture improvement combined with dingo control could increase sheep numbers by 93%.

Table 2: Sheep losses caused by dingoes over an 18-day period, detected during radio-tracking in two areas on Mardie Station, Western Australia where dingoes were being controlled (after Thomson 1984a).

	Area A	Area B
Radio-collared dingoes involved	3	6
Potential sheep available	800	4200
Harassments, no injuries	5	3
Minor injuries	1	3
Kills/mortal injuries	13	26
Other verified deaths	0	7
Total identifiable losses	**17***	**33**

*Total includes four sheep killed on a neighbouring property by one of the radio-tagged dingoes.

'There were seasonal peaks in predation, possibly related to the seasonal breeding of wild dogs and control activity, as well as the timing of lambing and calving.'

The surveys of dingo damage (Table 3) conducted by NERDA (c. 1966) and Schaefer (1981) were inherently biased because their samples were obtained from graziers attending meetings to discuss the issue of wild dog predation. Fleming and Korn (1989) report a monthly survey of authorised wild dog control officers (of Rural Lands Protection Boards) from eastern New South Wales over the four years from 1982 to 1985 (Table 3). During this period, 25 644 livestock were attacked by wild dogs. Sheep were the most commonly attacked animal, followed by cattle and goats. Regional differences were apparent in the livestock species attacked and these reflected the ratio of sheep to cattle grazed in each region. Not surprisingly therefore, the major losses occurred in areas where sheep were present. Fleming and Korn (1989) found seasonal peaks in predation, possibly related to the seasonal breeding of wild dogs and control activity, as well as the timing of lambing and calving.

In 1984 and 1985, another survey of 111 randomly selected livestock producers with land close to or within terrain inhabited by wild dogs was conducted in north-eastern New South Wales (Table 3; Fleming 1987). Thirty-six per cent of producers reported that wild dogs had attacked their livestock during the survey and 1194 sheep and 127 cattle were killed in those attacks. The mean losses during the survey were 7.17 sheep per property per year and 0.76 cattle per property per year. The mean value of losses suffered by those participants that had livestock preyed on by wild dogs was $1900 (Fleming 1987). The mean value was largely dependent on the values of livestock that prevailed during the survey. The cost to the sheep industry of predation by wild dogs in eastern New South Wales for 1988 was estimated at around $4 million (Saunders and Fleming 1988). Of the surveys undertaken in north-eastern New South Wales, only one survey (Fleming 1987) was an unbiased sample from landholders within or adjacent to terrain inhabited by wild dogs.

In 1985, Backholer (1986) mailed a questionnaire to 809 properties in 23 shires of Victoria that had a history of livestock predation by wild dogs. The 508 respondents reported mean losses per property of

Table 3: Predation of livestock by wild dogs in north-eastern New South Wales. Mean losses were calculated as the total number of sheep killed by wild dogs divided by the total number of sheep run by the survey participants and expressed as a percentage (from Fleming 1996b).

Year(s)	Sheep killed (Number/property/year)	Mean losses of sheep (%)	Source
1961–62	19.5[a]	1.33	NERDA (undated c. 1966)
1980–81	19.4	0.9	Schaefer (1981)
1982–85	N/A	0.7[b]	Fleming and Korn (1989)
1984–85	14.5	0.8	Fleming (1987 and unpublished data 1985)

[a]To equate the data with previous biased surveys (NERDA undated, c. 1966; Schaefer 1981), only the losses of Wild Dog Control Association members in Fleming (1987) are presented in this column.

[b]Losses reported to local Rural Lands Protection Boards multiplied by three to account for two-thirds under-reporting recorded in Fleming and Korn (1989).

between $700 and $7400 per annum, 0.1 to 24.9% of the total value of the enterprises. The total loss was $835 000. As well as this, opportunity costs (including time, moving stock, repairing fences) totalled $662 500 and government agencies spent $1 444 500. Therefore the total annual loss was around $3 million. During the preceding eight years, the annual average of the total losses that were reported in the surveyed area was 2400 sheep which would be equivalent to an average annual loss of $1650 per property (Backholer 1986).

The most recent survey of livestock losses inflicted by wild dogs was in the Northern Territory in 1995. The results of a questionnaire of approximately 67% of pastoralists led to a rough estimate that annual calf losses attributable to predation by wild dogs were between 1.6% and 7.1% (Eldridge and Bryan 1995). The estimated annual value of all cattle killed by wild dogs in the Northern Territory (assuming an average value of $540 per head and 100% calving — such calving rates are optimistic) was $13.5 million with control costs of $300 000. This represents average losses of $89 000 per property and costs of $2000 per property. Despite the extreme losses and comparatively small investment in wild dog control, 96% of respondents rated wild dog control as being worthwhile.

One of the difficulties in providing clear data on the impact of wild dogs on livestock production is that most wild dog control programs manage to achieve, at least to some extent, their aim of reducing predation on livestock. Thus, figures on losses or damage can be misleading, rarely reflecting the potential impact that could arise in the absence of wild dog control. The economic impact of wild dog predation of livestock cannot simply be measured in terms of livestock killed by wild dogs. Losses other than direct maimings and killings of livestock caused by wild dogs are especially difficult to quantify. The costs of control activities, losses of genetic material, capitalisation of the risk of wild dog predation into land values (Schaefer 1981) and opportunity costs (such as the allocation of labour and capital to predation mitigation and planning instead of other on-farm activities) need to be accounted for in economic assessments. Other opportunity costs are the imposition of sub-optimal enterprise mixes for a particular agro-environment and sub-optimal pasture management caused by the presence of

(a) Calves are most vulnerable to wild dog attack when they are newborn and left while the cow feeds; (b) 'nursery groups' of calves protected by older cows are common in areas where cattle are familiar with wild dog attacks (Source: L. Allen, Department of Natural Resources, Queensland).

wild dogs. Although the mix of sheep and cattle may be partially offset by capitalisation of the costs of wild dogs into the purchase price of land, enterprise mixes that are below the optimum are likely to negatively affect the cash flows and long-term profitability of grazing enterprises in wild dog inhabited areas.

'Figures on losses or damage can be misleading, rarely reflecting the potential impact that could arise in the absence of wild dog control.'

Despite potential shortcomings, surveys of the type outlined above substantiate the generally accepted view that the major losses caused by wild dogs occur amongst sheep flocks. An attempt to specifically document and quantify the types of losses caused to sheep flocks was made on Mardie Station in the Pilbara region of Western Australia (Thomson 1984a). In this study, 26 radio-collared dingoes in sheep paddocks were observed from the air. Interactions with sheep were followed up by investigations on the ground. Additional information was obtained when sheep were mustered and inspected at shearing time. The major findings were:

- Some dingoes caused far more damage than others did, although most attacked sheep, sometimes maiming without killing outright.
- The presence of a dingo could adversely affect the distribution and behaviour of the sheep, even if the dingo did not actively harass them.
- Dingoes sometimes chased sheep without following through with an attack. This could still lead to harm such as mismothering of lambs.
- When dingoes killed sheep they often left carcasses uneaten.
- Individual dingoes that frequently killed sheep often ate natural prey such as kangaroos (*Macropus* spp.).

Dingoes easily outpaced sheep, although it was clear that many of the witnessed chases were not motivated by hunger; chases were sometimes seen after wild dogs had been observed feeding. At times wild dogs simply broke off chases, or moved on to chase other sheep in the mob, then left with no actual physical contact with the sheep. Sheep were sometimes chased through fences (this has also been reported in north-eastern New South Wales), on occasions into waterless areas. At times, clear changes in the distribution of sheep within large (up to 150 square kilometres) paddocks were observed; sheep abandoned favoured grazing areas when dingoes were present. When ewes and lambs were chased, ewes ran off wildly, leaving lambs to keep up as best they could and potentially causing their death through mismothering. All these events could cause production losses, although they would not necessarily be reflected in a 'carcass count'.

The survival of most bitten sheep was poor. Far fewer bitten sheep were tallied at shearing than would have been expected based on observations in the paddocks. Nevertheless, rams seemed to survive severe scrotal injuries, with some being fully castrated by wild dogs attacking from behind (Figure 11).

In some areas, producers have elected to run cattle instead of sheep because of the effects of wild dog predation. For example, Backholer's (1986) survey showed that, to minimise wild dog predation, 12% of eastern Victorian respondents reduced their sheep numbers or did not run sheep. Although wild dogs can cause losses to cattle herds, as discussed next, the impacts are usually less severe and more easily overcome. Nevertheless, some grazing lands are more suited to running sheep than cattle, and the move to other enterprises such as cattle production can be viewed as an opportunity cost of wild dog predation.

Damage by wild dogs is likely whenever their ranges overlap those of sheep. Damage occurs largely independent of age and condition of sheep, age and density of the dogs, seasonal conditions and availability of alternative food for dogs. However, most of these factors influence wild dog predation on cattle (Rankine and Donaldson 1968; Corbett 1995a; Allen and Gonzalez 1998). In contrast to the situation with sheep, the impact of wild dogs on cattle production is more variable. Generally, attacks on young calves are the major cause of cattle losses to wild dogs (Corbett 1995a; Fleming and Korn 1989). However, the cost of wild dog predation to the beef industry in Australia has not been estimated. The profitability of northern Queensland cattle enterprises is substantially affected by branding percentage (Sullivan et al. 1992). Predation of calves by wild dogs is the main cause of neonatal losses in northern Australian cattle (Rankine and Donaldson 1968) and hence has major bearing on branding precentage. Branding percentages also vary considerably with seasonal conditions, pasture improvement and level of animal husbandry. Predation is greater when alternative food is scarce (Thomson 1992c; Corbett 1995a; Allen and Gonzalez 1998). Improved weaner management and nutrition have been shown to potentially increase branding percentages from 40% in 1968–69 to 1970–71 (Anderson and McLennan 1986) to 80% twenty years later (Fordyce and Entwistle 1992).

'Predation may be higher when control operations cause invading young wild dogs to come into contact with cattle herds.'

Estimates of predation losses of calves and weaners in normal conditions in rangeland grazing areas are in the range of 0–29.4% per year (Rankine and Donaldson 1968) and studies of reproductive failure in cattle herds in Queensland have suggested up to 30% loss of calves caused by predation by wild dogs (Allen and Gonzalez 1998). Such losses would negate the potential gains due to improved livestock and pasture management in northern Australia.

There is evidence that the age and social organisation of a wild dog population can affect the extent of predation on calves. Calves are most vulnerable when newborn, though the protective behaviour of the cow can be sufficient to deter wild dog attacks (Thomson 1992c, and unpublished observations). Experienced wild dogs, operating as a hunting unit, are more likely to be successful at killing calves. On the other hand, there is evidence from north Queensland (Allen and Gonzalez 1998), that risks of predation may be higher when control operations cause a preponderance of invading young wild dogs to come into contact with cattle herds. Seasonal effects (Corbett 1995a) and the scale of control may modify the damage response; a larger baited area would reduce the rate of repopulation and the number of transient dogs, as Thomson (1984b) found in Western Australia.

It is possible that increased predation could be caused by the greater mobility of immigrant dingoes, increasing the probability of an encounter with a newborn calf. This might be exacerbated by the lone status and relative inexperience of immigrant wild dogs, resulting in their poor success at hunting larger and faster native prey such as kangaroos.

Appropriate strategies to manage the impacts of wild dogs differ markedly depending on the type of livestock and the conditions prevailing in an area (Chapters 5, 6 and 7).

3.2 Environmental impact

Predation by wild dogs may have an impact on the survival of remnant populations of endangered fauna. For example, predation by the dingo has been implicated in the extinction of the Tasmanian native-hen (*Gallinula mortierii*) from mainland Australia (Baird 1991). Endangered populations of marsupials may require management of their predators to become re-established or to survive (Johnson et al. 1989). Predation by wild dogs is less likely to threaten populations of more abundant marsupials (Robertshaw and Harden 1989).

The other environmental impacts of wild dogs relate to their management, rather than to the presence of the animals themselves. First, control measures may have a direct impact on non-target species (Section 6.6.2). Second, reducing wild dog density may result in an increase in other predators with overlapping diets. (This process of substitution of predators is called 'mesopredator release' (Soulé et al. 1988)). There is a commonly held opinion (Denny 1992; Smith et al. 1992) that removing wild dogs from a system where foxes (*Vulpes vulpes*) also occur will result in an increase in fox numbers with consequent increased predation on critical body weight range (CWR) mammals (35–5500 grams) (Burbidge and McKenzie 1989). However, neither an increase in fox numbers resulting from a reduction in wild dog numbers nor a resulting increase in predation of CWR mammals have been demonstrated. Schlinder (1974) has also argued that, by the same mechanism, feral pigs could replace dingoes in some situations.

'Predation by wild dogs may have an impact on the survival of remnant populations of endangered fauna.'

Predation on environmentally damaging feral ungulates has been suggested as a positive impact of dingoes and other wild dogs. For example, Parkes et al. (1996) suggested that the limited distribution of feral goats in northern Australia was attributable to dingo predation. Twenty sterilised dingoes were released on Townshend Island, off Queensland, in an attempt to reduce the population of 2000–3000 feral goats. Within one-and-a-half years 99% of the goats had been removed and feral goats were eradicated from the island after three-and-a-half years (L. Allen, Queensland Department of Natural Resources, pers. comm. 1998). Given that the dingoes survived for two years on very few goats, this raises the interesting question of the impact of dingoes on alternative prey (Section 3.6.5) that must have been killed during the latter part of the exercise. Caution should be exercised in translating these results to mainland ecosystems. Pavlov (1991) provided circumstantial evidence that, while dingoes undoubtedly kill feral pigs, they do not significantly affect feral pig abundance.

3.3 Resource and conservation value

Although feral dogs and hybrids are seldom regarded as a wildlife resource, dingoes have potential value from five resource perspectives: (1) harvest for food or skins; (2) conservation of native species and natural communities (Section 4.4); (3) in Aboriginal mythology; (4) tourism; and (5) as a specialised dog breed.

1. Unlike in some Asian countries where dingoes are eaten (Corbett 1995a), there is no current harvest of dingoes for food in Australia. There is evidence that Aboriginal people ate dingoes and other wild dogs (Manwell and Baker 1984). Dingoes could be harvested for their pelts, but these are generally of low value. It is illegal under the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* and subsequent amendments, and associated *Amendment Acts of 1986, 1991 and 1995*, to export native wildlife products, including pelts, without appropriate licenses. Trade in skins, except for the recovery of bounties, is not permitted in those States and Territories where the dingo is afforded some conservation status.
2. The dingo has been in Australia long enough to have colonised most suitable habitats and, in many instances, is still a functional part of predator–prey relationships. The implication from this is that the dingo fulfils an important role in the functioning of ecosystems. Legislation in some States acknowledges the ecological significance of dingoes and provides protection in some situations (Section 5.2). Whether dingoes have conservation value because they have a functional role in the conservation of natural ecosystems is unclear (Sections 3.4, 3.5 and 3.6). Regulation of macropod and emu (*Dromaius novaehollandiae*) populations by wild dogs has been inferred, but not proven, in a number of studies (Caughley et al. 1980; Shepherd 1981; Robertshaw and Harden 1986; Thomson 1992c; Fleming 1996b; Pople et al. 2000). Prey regulation by wild dogs has been inferred for rabbit populations after droughts have reduced rabbit numbers in arid areas (Corbett 1995a). Conversely, in an experiment in the wet–dry tropics, Corbett (1995c) demonstrated that dingoes do not regulate feral pig populations (Section 3.6.5).

In contrast, there is evidence that dingo numbers in many areas of central and northern Australia have increased since

European colonisation. Predation by dingoes may threaten the survival of some CWR mammals. Where this occurs, dingoes may be considered a biological liability rather than a biological resource. Where feral dogs and hybrids have supplanted dingoes, these too may perform a similar role in the function of the ecosystem. Predators affect the distribution and abundance of their prey (Huffacker 1970) and so the substitution of one canid subspecies with a similar subspecies is likely to maintain the dynamics of the community in which they occur.

3. The dingo is an important animal in Aboriginal mythology. For some Aboriginal peoples (for example, the Pitjantjatjara) dingoes are associated with sacred sites and are considered the physical embodiment of a Dreamtime character or Tjukurpa. The local disappearance of native species significant to Aboriginal people has caused them distress in the past and similar distress may be caused if dingoes become extinct.

4. Dingoes provide an indirect resource value from tourism. They are present in many zoos and private wildlife parks. Fraser Island is an example where free-living dingoes are a tourist attraction providing income to island businesses. Tourism by recreational hunters is another source of value of dingoes (Allison and Coombes 1969). The 'howling-up' of a dingo may be regarded as a test of hunting skills and the presentation of scalps for bounties (Section 5.1.1) as a small remuneration to help cover the costs of the hunt (Allison and Coombes 1969).

5. The dingo is recognised as an official breed of dog by the Australian National Kennel Council and was adopted as Australia's national breed in November 1993. In New South Wales, this status has been recently recognised in legislation (*Companion Animals Act 1998*) which allows people to keep dingoes under the same restrictions as other breeds. Animals kept by breed societies are traded as pets or specimen animals. This is potentially damaging for the conservation of pure dingoes because many animals held by breed societies are likely to be hybrids and there are no valid checks in place to detect them (Corbett 1995a; Corbett in press; Section 2.9).

The presence of dingoes has an 'unpriced' value (Sinden and Worrell 1979) that is difficult to quantify and comprises the non-monetary value that many people place on dingoes. The dingo is an icon which many people value knowing is present in the wild, that is, its 'existence value'.

3.4 Diseases and parasites

Endemic diseases and parasites

Hydatidosis (causal agent *Echinococcus granulosus*) causes fatalities and morbidity in humans. The prevalence of hydatidosis in humans is often linked to sylvatic cycles in wild dogs and wildlife (Coman 1972a; Thompson et al. 1988). The prevalence in humans is relatively low but is more common in south-eastern Australia (Jenkins and Power 1996).

Hydatidosis associated with a sylvatic cycle within wild canids and macropods (Durie and Riek 1952; Coman 1972b) leads to the condemnation of offal from up to 90% of slaughtered cattle from endemic areas (D. Jenkins, Australian Hydatids Control and Epidemiology Program, unpublished data 1999). An abattoir survey of sheep from the Southern Tablelands of New South Wales from 1970–72 found hydatidosis in up to 40% of carcasses (Hunt 1978). Bovine hydatidosis (causal agent *Echinococcus granulosus*) prevalences of 2.2–55.7% have been reported in south-eastern Queensland (Baldock et al. 1985) and of 0.5–7% in north-eastern Victoria (D. Jenkins, Australian Hydatids Control and Epidemiology Program, Australian Capital Territory, pers. comm. 1998). The latter prevalences were in spite of an extensive hydatid control program aimed at domestic and farm dogs. Hydatidosis is an occupational risk for wild dog trappers and researchers.

Red foxes have also been identified as definitive hosts and macropods as intermediate hosts for hydatid transmission in south-eastern Australia (Obendorf et al. 1989; Reichel et al. 1994). Where feral dogs, dingoes and free-roaming domestic dogs co-occur with foxes (for example, in coastal south-eastern Australia, Meek 1998) the control of human hydatidosis becomes more difficult.

'The prevalence of hydatidosis in humans is often linked to sylvatic cycles in wild dogs and wildlife.'

Wild dogs also transmit the viruses that cause canine distemper (Paramyxovirus), canine hepatitis (Adenovirus) and parvovirus disease (causal agent Parvovirus). Although these diseases adversely affect domestic dogs, their transmission by wild dogs is unlikely to pose a significant threat because these diseases can be controlled.

The presence of heartworm (*Dirofilaria immitis*) in dog populations is linked to the presence of mosquitoes in endemic areas (Russell 1990). Heartworm infections are uncommon in the tablelands of south-eastern Australia, with most cases of infection in domestic dogs being in animals that have been moved by their owners to and from endemic areas (Carlisle and Atwell 1984). Heartworm infection has not been recorded in foxes from the Northern, Central and Southern Tablelands of New South Wales (P. Fleming and B. Kay, NSW Agriculture, and D. Jenkins, Australian Hydatids Control and Epidemiology Program, Australian Capital Territory, unpublished data 1999). It is therefore unlikely that wild dogs and dingoes from tablelands of south-eastern Australia will experience heartworm infection and that, more commonly, infection will be in coastal areas and northern Australia. In urban Melbourne, where heartworm infection has been recorded in foxes, a sylvatic cycle of canine heartworm has been postulated (Marks and Bloomfield 1998). This process may also apply in endemic areas where foxes and wild dogs co-occur.

Seddon and Albiston (1967) suggest that wild dogs may act as hosts for the parasite that causes sheep measles (*Taenia ovis*) and the consequent condemnation of sheep carcasses. However, Coman (1972a) failed to find evidence of *T. ovis* infection in a sample of 204 dingoes and other wild dogs in north-eastern Victoria and linked this absence to the infrequent occurence of sheep and cattle in the diet of dogs in his sample.

Parasites have also been instrumental in the identification of dingo origins. The occurrence of the biting lice (*Heterodoxus spiniger*) on dingoes and macropods in Australia and on Asian dingoes implies that dingoes were transported to and from Asia (Corbett 1995a) (Section 1.2).

Exotic diseases and parasites

Canids are regarded as the most important source of rabies (Rhabdoviridae) in humans (Garner 1992), with dogs causing an estimated 75 000 cases annually throughout the world (Fenner et al. 1987). As dog rabies is presently exotic to Australia (there has been one reported outbreak since European settlement in Tasmania in 1867; O'Brien 1992), the potential role of wild dogs can only be speculated. Newsome and Catling (1992) suggest that of all Australian wildlife, wild dogs and foxes pose the greatest risk of maintaining and spreading dog rabies after introduction, and Thomson and Marsack (1992) propose aerial baiting of buffer zones as the primary weapon against the spread of rabies among dingoes in rangelands. Forman (1993) indicated that the establishment of a sylvatic dog rabies cycle in Australia was remote but possible. The dog strain of rabies remains the main focus for quarantine barrier prevention of this disease in Australia.

If dog rabies were to become endemic in Australia, interaction between free-roaming dogs and feral dogs and dingoes would be the most likely avenue for dog rabies transmission to humans. Free-roaming dogs have been recorded making linear movements of up to eight kilometres into bushland where wild dogs and foxes co-occur (Meek 1998). These animals entered bushland with high macropod density to hunt and then returned to their owners. The mean duration of hunting forays was 23 hours, and it is probable that interactions between wild and free-roaming dogs occurred on these trips. Newsome and Catling (1992) consider that, at the high densities of wild dogs and dingoes found in northern Australia and south-eastern Australia, dog rabies would persist were it introduced. Interactions of unrestrained and unvaccinated domestic dogs with wild dogs would contribute to human infection if rabies were to become established in wild dogs. Rabies is not solely a problem of human health but also affects livestock production; for example, bat rabies from vampire bats (*Desmodus rotundus*) is a serious cause of mortality in cattle in Central and South America (Garner 1992). Should a sylvatic cycle of dog rabies become established in wild dogs in Australia, it might affect sheep and cattle production and make the treatment of animals injured by wild dogs more risky.

'Wild dogs and foxes pose the greatest risk of maintaining and spreading dog rabies after introduction.'

A number of other diseases are important pathogens of dogs in other parts of the world and their introduction to Australia would adversely affect domestic dogs, particularly in breeding kennels, in much the same way as canine distemper does. Wild dogs at high densities may also be affected and their populations limited by infection levels. Among these diseases are: canine brucellosis (infective agent *Brucella canis*), which causes abortion and infertility; Chagas' disease (*Trypanosoma cruzi*), which may cause myocardial and central nervous system degeneration; and tropical canine pancytopaenia (*Ehrlichia canis*), an often fatal parasite of the blood associated with the common brown dog tick (*Rhipicephalus sanguineas*) (Geering and Forman 1987). Canine brucellosis and Chagas' disease are both zoonoses when endemic but human infections are few. Geering and Forman (1987) suspect that tropical canine pancytopaenia may be present in northern Australian wild dogs although no positive diagnoses have been made.

Dogs are also susceptible to infection by three other exotic disease organisms: the viruses causing Aujeszky's disease (Herpesviridae, Alphaherpesvirinae) and transmissible gastroenteritis (Coronaviridae), and screw-worm fly (*Chrysomya bezziana*) (Saunders et al. 1999). Wild dogs might spread transmissible gastroenteritis, a disease affecting young pigs, but dogs are unlikely to be important in spreading the other two diseases if they were to enter Australia.

3.5 Interactions between wild dogs, marsupial carnivores and introduced predators

The thylacine (*Thylacinus cynocephalus*), a marsupial carnivore about the size of the dingo, was once distributed throughout Australia, but 'suddenly' disappeared from the mainland about 3000 years ago (Archer 1974; Dixon 1989; Rounsevell and Mooney 1995). The Tasmanian devil (*Sarcophilus harrisii*), a marsupial carnivore about half the size of a dingo, was also widespread throughout Australia about 4000 years ago, but its population declined and it became extinct on the mainland about 450 years ago (Jones 1995). Their demise can be attributed to competition with dingoes according to the 'superior adaptability' hypothesis (Corbett 1995a). This hypothesis hinges on the superior social organisation of dingoes during critical periods when food supplies were scarce, widely dispersed or clumped, which usually occurs during drought or after extensive wildfire. Only dingoes form large integrated packs and cooperate to catch large prey and to defend carcasses, water and other crucial resources. On the other hand, thylacines hunted alone or in pairs and devils were essentially solitary so that neither could successfully compete against the weight of dingo numbers during those critical periods.

This contention is supported by early records of thylacines as having a stiff gait; they probably could not run after their prey (mainly macropods) as fast as dingoes could. They apparently located prey by scent and tired it by dogged pursuit, usually alone, as there are no records or anecdotes of thylacines hunting cooperatively. This apparent lack of pack hunting is supported by bushmen's observations that the thylacine was normally mute except for a coughing bark (Rounsevell and

Mooney 1995). Social hunters, such as dingoes, have a large vocal repertoire for communicating over distances (Corbett 1995a). Similarly, observations of devils in Tasmania, where they are still common, confirm that they hunt alone, and that although they can catch a variety of live prey, they subsist mainly on carrion such as macropods and sheep (Pemberton and Renouf 1993). It seems that their aggregations around carcasses are not cohesive social units, so, as for thylacines, it is quite likely that devils could not successfully compete with dingoes when food was scarce during drought and after fires.

'Dingoes form large integrated packs and cooperate to catch large prey and to defend carcasses, water and other crucial resources.'

Wild dogs may now present foxes and feral cats with a similar kind of competition. In central Australia, the most common prey species of wild dogs, foxes and feral cats are rabbits and small rodents. During a drought between 1969 and 1972 these prey became scarce and wild dogs changed their diet to red kangaroos (*Macropus rufus*) and cattle carcasses (Corbett and Newsome 1987). Wild dogs were more successful at catching kangaroos by hunting cooperatively than alone (Section 2.3.1), and stable packs of wild dogs defended carcasses and waters more successfully than less cohesive groups (Corbett 1995a). During the first year of this drought, cats and foxes were also seen scavenging cattle and kangaroo carcasses, but sightings of them ceased and their tracks disappeared about midway through the drought. They most likely starved because many emaciated cats suddenly appeared around homesteads and many were easily killed by park rangers (Hooper et al. 1973). Wild dogs undoubtedly contributed significantly to the demise of cats and foxes by their increased monopoly of carcasses as the drought persisted. Foxes were observed avoiding wild dogs at shared waterholes and an increase of cat in the wild dogs' diet was recorded. In any event, there were no signs of cats or foxes until the drought broke and after the rabbit and rodent populations had resurged (Corbett 1995a).

3.6 Predator–prey relationships

Dingoes and other wild dogs have changed in abundance and status since European settlement led to modified ecosystems (Section 2.8.4), and so has the nature of their sociality and predation.

3.6.1 Dingo behaviour and predation on cattle

There are potential problems if peak calving coincides with the dingo mating season. For example, in the Barkly Tableland of the Northern Territory, most dingoes operate independently but during the dingo mating season (about four months peaking in March–April), dingoes form temporary breeding groups which often comprise one oestrous female and several males (Corbett 1995a). The dingo mating season coincides with the peak in calving and this coincidence contributes to the deaths of many calves (Corbett 1995a). Calves and dingoes are often together at water, which is where many attacks occur. In many cases, attacks on calves are probably more of a displacement activity than a hunger drive, perhaps because dingoes become frustrated from competing over oestrous (in heat) females and fighting with rival males. Within dingo groups, there are many aggressive interactions between males but actual fighting is uncommon because of complex behaviours associated with dingo dominance hierarchies. Aggressive behaviour can be appeased or diverted by submissive behaviour to avert serious wounding and death (Corbett 1988b). However, a calf cannot appease or divert the aggression as a submissive dingo would, so the dingo, irrespective of social rank, continues to attack, often joined by other dingoes, until the calf becomes wounded or dies. Calves killed this way are rarely eaten. Even if the calf survives well enough to be sent to market, the meat is often classified as second class because of scars from dog bites. Such loss to the cattle industry is probably substantial but it is difficult to quantify (Section 3.1). As wild dogs seldom eat calves, examining stomachs or faeces of wild dogs would be misleading.

3.6.2 Extinctions of native fauna in central Australia

In central Australia, before the 1930s, 14 species of bandicoots (Peramelidae), macropods and rat-kangaroos (Potoroidae) were common in the areas where cattle now graze, but only five species survive today, and of these, two are rare and endangered (Newsome and Corbett 1977; Morton 1990).

It is probable that a combination of factors operated to cause those extinctions and declines including:

- habitat fragmentation and modification from heavy grazing by rabbits and livestock
- increased competition from rabbits and livestock
- altered fire regimes
- predation by feral cats, foxes and dingoes.

With respect to predation, Corbett (1995a) indicates that cat and fox numbers were low at the time and that dingoes played a major role in the demise of those medium-sized mammals that mostly sheltered on the surface amongst grass and shrubs.

The expansion of grazing enterprises from the 1930s was due to the establishment of supplementary water from artesian bores (Bauer 1983), which allowed cattle to graze further from natural water sources and modify and fragment habitats. This expansion coincided with the most severe droughts (Foley 1957) on record and widespread severe grassfires (Friedel et al. 1990) (Figure 8).

During drought the native fauna declined. In contrast, dingo populations remained high due to cattle carrion and water provided for stock. Dingo predation on macropod and bandicoots would have become increasingly severe as dingo populations grew and as the protective shelters were removed by cattle and rabbits. It is probably no coincidence that the native mammals became extinct or rare.

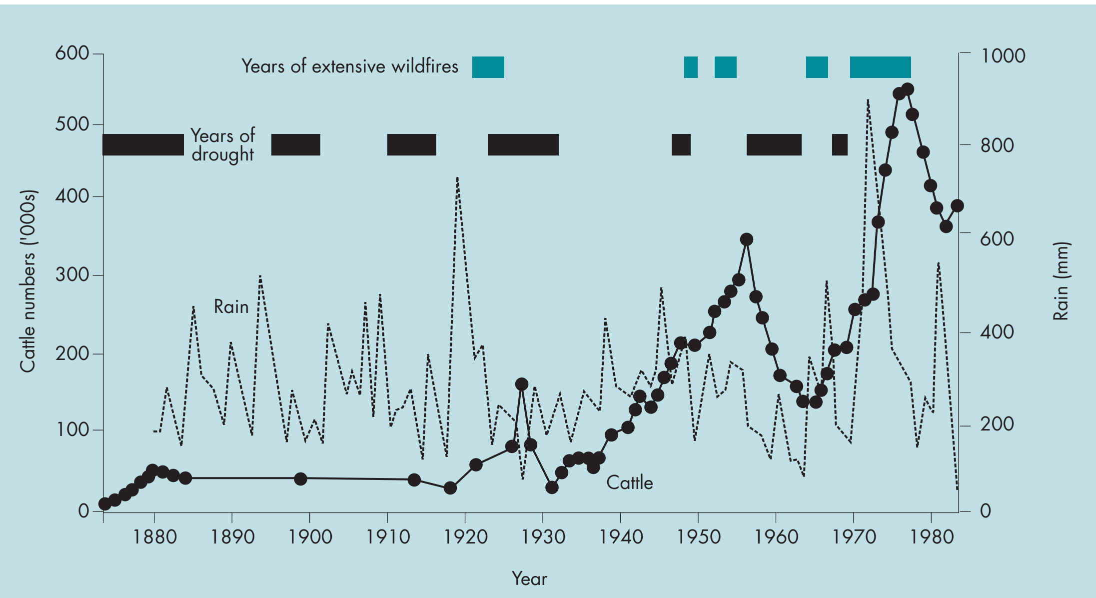

Figure 8: Cattle numbers and rainfall in central Australia from 1874 to 1985. The increase in cattle numbers from the 1930s corresponded with the availability of sub-artesian bore water. Droughts are unpredictable and common in arid areas, yet cattle numbers quadrupled between the worst droughts (1924–1930 and 1958–1965). Wildfires became more frequent in the 20th century. The combination of extensive fierce fires and cattle grazing exposed many medium-size mammals to predation by wild dogs. This predation was probably a cause of some native species' extinctions (after Corbett 1995a).

3.6.3 Factors affecting wild dog–prey interactions with native prey

In the tropical coastal wetlands of the Northern Territory, most dingoes live in packs of three to eight and defend more or less fixed territories. They mostly eat dusky rats (*Rattus colletti*), magpie geese (*Anseranas semipalmata*) and agile wallabies (*Macropus agilis*). When these prey are unavailable dingoes can switch to a range of at least 33 species of substitute prey although they usually concentrate on only one or two species at a time (Corbett 1989; 1995a).

Wallabies are available all year round whereas the supply of rats and geese varies with wet and dry seasons. Most geese are eaten as fledglings in the dry season. Rats irrupt into huge plagues on the floodplains about every three or four years, but they are only available to dingoes during the dry months. Floodplain fauna (rats and geese) are mostly eaten during the dry months and more forest fauna (wallabies (*Macropus* spp.) and possums (Phalangeroidea)) are eaten during the wet months (Figure 9).

Climatic conditions influence both when and where dingoes hunt particular prey species. This alternation of predation between habitats, illustrated in Figure 9, is a well-defined, predictable cycle in which dingoes do not appear to influence the abundance and diversity of any particular prey.

In the temperate coastal mountains of south-east Australia wild dog–prey interactions are determined more by wildfire than by rainfall. Most fires are low to moderate intensity so that the environment remains fairly stable and food supplies for wild dogs are usually high. Fires of high intensity, although infrequent, devastate entire forests and change the prey available to wild dogs, but the total food supply usually remains high. It is therefore not surprising that the predatory cycle is less defined than in the tropical wetlands. Lower densities of wild dogs living in smaller packs (averaging three members) and in smaller territories are also a consequence of this environmental stability (Newsome et al. 1983a).

This predatory cycle still alternates between consistently available prey and seasonal

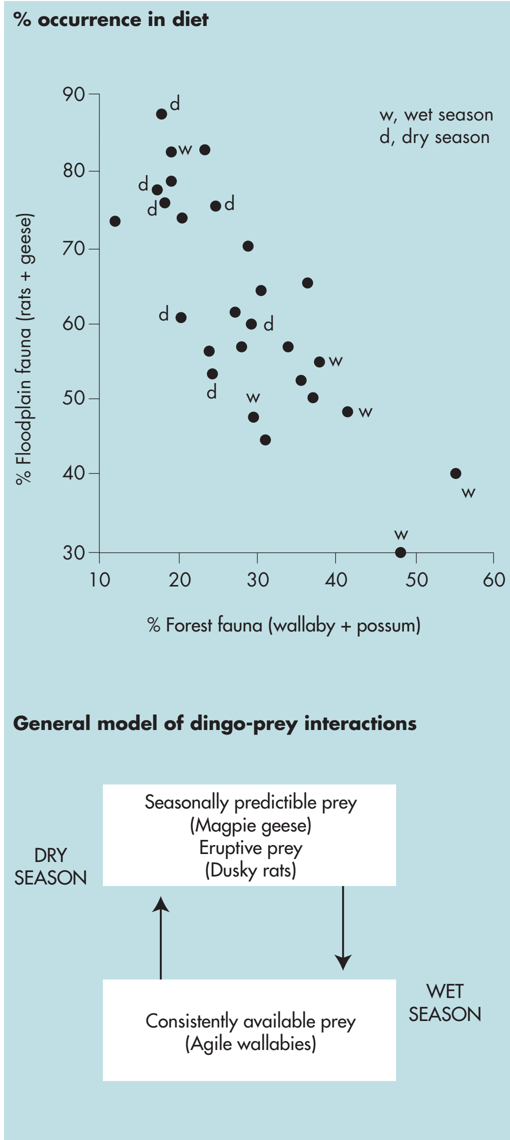

Figure 9: A model of predation by wild dogs in a pristine coastal ecosystem in tropical Australia. Predation by wild dogs alternates between habitats, switching from forest during the wet season to floodplain in the dry after the floodplains dry out. The main prey are dusky rats and magpie geese in the dry and agile wallabies in the wet (after Corbett 1995a).

prey. At Nadgee Nature Reserve in south-eastern New South Wales, for example, the main prey are medium-sized mammals (wallabies, rabbits, possums) and waterbirds such as black swans (*Cygnus atratus*) and coots (*Fulica atra*). Both prey types are eaten seasonally and are supplemented by large macropods (eastern grey kangaroo)

(*Macropus giganteus*) and small mammals (Newsome et al. 1983a). In this ecosystem wild dog predation sometimes affects prey diversity, abundance and population structure, probably because severe wildfires change habitats and thus alter the composition of the prey base. This encourages wild dogs to either concentrate on a vulnerable, relatively uncommon species, or to prey on an abundant species, thereby relieving the pressure on another species and allowing its population to recover. At Nadgee, wild dogs usually concentrate on macropods immediately after severe fires and sometimes eliminate local populations of eastern grey kangaroos (Newsome et al. 1983a).

'The predatory cycle alternates between consistently available prey and seasonal prey.'

The effects of such intense predation is alleviated when waterbirds are in great abundance, as sometimes occurs when severe storms replenish the coastal lakes with water and food for the birds. When there are no substitute prey available after severe fires, wild dog numbers decline soon after macropods decline (Newsome et al. 1983a).

In the mountains, where waterbirds are less available, there is no clear cycle. In Kosciusko National Park, wild dogs mainly hunt wombats (*Vombatus ursinus)*, wallabies and rabbits, and these prey are supplemented by a variety of other species (Newsome et al. 1983a). Similarly, in the mountains near Armidale in north-east New South Wales, the main prey of wild dogs are macropods, especially swamp wallabies (*Wallabia bicolor*), red-necked wallabies (*Macropus rufogriseus*) and eastern grey kangaroos (Robertshaw and Harden 1985a; 1985b). Wild dogs concentrate on juveniles (pouch young and young at foot) and reduce macropod recruitment rates so considerably that the populations of these species may decline. In some areas, small isolated populations of eastern grey kangaroos and red-neck wallabies have been completely eliminated (Robertshaw and Harden 1986). This happened because enough substitute prey was available to support the wild dog population; otherwise the wild dogs would have moved away or starved.

Another outcome of the wild dogs' concentration on swamp wallabies was a disruption of the usual seasonal pattern of wallaby births (Robertshaw and Harden 1986). Many females ejected their pouch young when pursued by wild dogs, but as most of these offspring were soon replaced (96% of sexually mature females carried a blastocyst), there was a continuous output of young instead of the usual spring–summer peak. Besides this change in breeding pattern, the number of ovulations per female increased as predation pressure of wild dogs increased, and so did male swamp wallabies' testicle and epididymis weights.

3.6.4 Factors affecting wild dog–prey interactions on pastoral lands

Two major environmental disturbance factors in much of Australia have been the introduction of exotic animals, especially rabbits and livestock, and pastoral industry infrastructure, such as artesian bores and dams. In temperate zones, land clearing has also changed the structure of the landscape. This alteration in habitats and introduction of exotic animals has made some native prey species increase and others decrease. Wild dogs have mainly benefited from extra supplies of food and water, which have helped them to survive drought and increase their numbers, but these extra resources have also changed the natural pattern of predation.

'Dingo predation is greatest on small and medium-sized mammals during flush periods and greatest on large mammals in drought.'

The interplay between seasons (drought and flush years), native prey and introduced prey (pests and cattle) and predation by dingoes is well illustrated by a study at Erldunda in central Australia (Corbett and Newsome 1987). When rains broke the longest drought on record (1958–65), rodents irrupted over widespread areas and dingoes concentrated on them for about a year. Then rabbits predominated in the dingo's diet for the next three years. When another drought reduced the rabbit populations, predation on red kangaroos increased, even though they became uncommon. Then, as this drought lengthened, cattle began to die and carrion became more frequent in the diet. This sequential emphasis upon vertebrate prey of increasing body size as aridity increased can be summarised as a general model (Figure10) which indicates that dingo predation is greatest on small and medium-sized mammals during flush periods and greatest on large mammals in drought. This seasonal variability provides a basis to understand the impact of dingo predation on prey, critical periods when dingoes kill cattle, and whether or not predation can regulate or limit prey populations.

3.6.5 Does predation by wild dogs regulate prey populations?

Predation by wild dogs has often been assumed to be a cause of fluctuation or lack of fluctuation in some prey populations, as indicated by the following examples:

- Wild dog predation has been assumed to account for the contrast in density of red kangaroos and emus on the two sides of the Dog Fence between the borders of Queensland, New South Wales and South Australia. Outside the fence, where wild dogs abound, kangaroos and emus are rare; but the opposite applies inside the fence (Caughley et al. 1980; Pople et al. 2000). There is evidence that, in this situation, the predation rate by dingoes on red kangaroos and emus regulates their populations at low densities (Pople et al. 2000).
- Feral goat populations persist only in areas where dingoes are absent or are subjected to high levels of control (Parkes et al. 1996).
- At Petroi, in the mountains of north-eastern New South Wales, the occurrence of swamp wallabies in the diet of wild dogs was proportionally higher than expected from the number of observed wallabies. When wild dog numbers increased, so too did their consumption of wallabies which was soon followed by a marked decline in the wallaby population (Robertshaw and Harden 1986).
- At Nadgee Nature Reserve, post-fire predation by wild dogs on macropods held their numbers in check for 2–3 years, probably because the fire opened up habitats and made these prey more vulnerable (Newsome et al. 1983a).
- In arid central Australia, red kangaroos became more vulnerable to predation during drought, partly because they were clumped around waterholes and remaining feed. At one site on the plains, kangaroo populations declined during a drought when dingo predation became progressively greater, and kangaroos remained low after drought — at about 15% of their pre-drought numbers (Corbett and Newsome 1987).
- In the Harts Ranges, near Alice Springs, Northern Territory, red kangaroos declined from being common to rare after a 7.5-year drought, and populations did not recover in the subsequent 10 years even though pasture was generally better than average. There is evidence that dingoes, whose numbers had remained stable throughout the drought, mediated competition between rabbits, cattle and kangaroos to the detriment of kangaroos (Corbett and Newsome 1987).
- In the Fortescue River region of north-west Western Australia, euro (*Macropus robustus erubescens*) populations were fairly low in an area where dingo populations were allowed to remain high, because they preyed selectively on particular age classes of euros. When dingoes were greatly culled by a baiting program, euro populations immediately and dramatically increased (Thomson 1992c).
- In the Guy Fawkes River region of northern New South Wales there is circumstantial evidence that dingoes limited the abundance of macropods (Fleming 1996b; Fleming and Thompson unpublished data 1993). It is possible that annual removals of wild dogs and foxes by aerial baiting increased the abundance of macropods in baited areas.

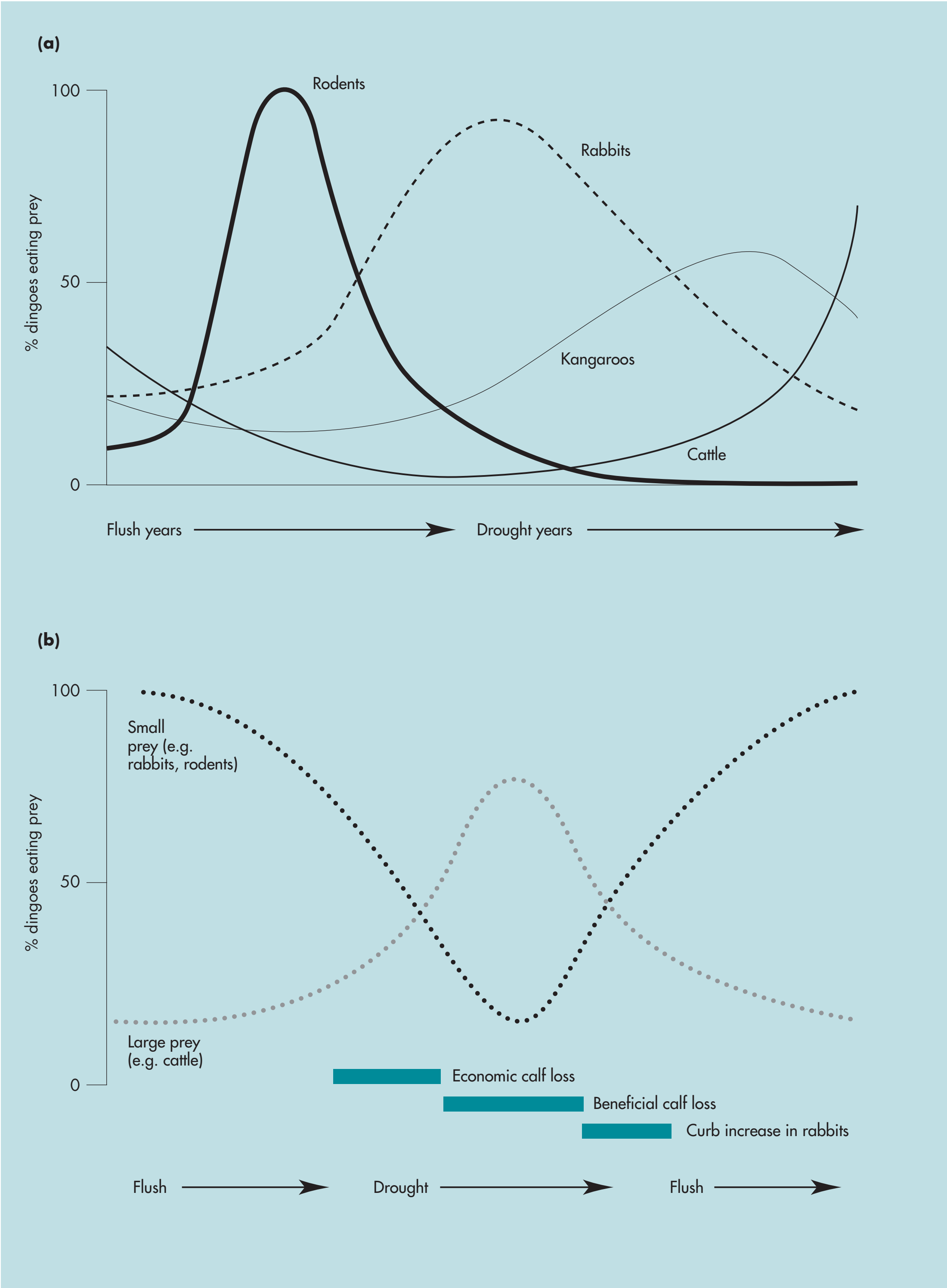

Figure 10: Models of predation by wild dogs in disturbed ecosystems in arid Australia showing: (a) sequential predation on prey of increasing size; and (b) dingo predation on small and large prey. Note, the time scale on the x-axis is longer in graph (b) (after Corbett 1995a).

These examples provide evidence that dingo predation can affect prey populations, especially macropods, but the long-term effect of this predation, and whether or not the effect is regulatory, cannot be assessed without experimental studies (Sinclair 1989). For some of the listed examples, alternative explanations could be feasible for the observed changes in prey abundance.

'Cattle carrion enabled dingoes to survive droughts and subsequently to concentrate on red kangaroos and perhaps regulate their population after a drought.'

In Queensland, analyses of bounties paid annually on wild dogs and feral pigs over 24 years indicated that pig mortalities increased more than threefold with every doubling of wild dog numbers, and this inverse relationship suggested that predation on pigs by wild dogs was a limiting and potentially regulating factor for populations of feral pigs (Woodall 1983). However, reanalysis of Woodall's data indicates that wild dog bounties were negatively related to rainfall over the previous year, suggesting that fewer wild dogs were killed in the 12 months following high rainfall (Choquenot et al. 1996). Correcting for the effects of rainfall removes the apparent relationship between pig mortality rate and wild dog density. Other problems with the analysis of scalp returns are identified in Section 6.2.1.

There has only been one experimental study to assess the impact of dingo predation on feral pig populations. This was at Kapalga in northern Australia and clearly demonstrated that predation alone did not regulate (see Glossary) feral pig populations. Instead, predation by dingoes was one factor acting in concert with interference competition from buffalo (*Bubalus bubalis*) to limit (See Glossary) feral pig numbers (Corbett 1995c). That is, feral pig numbers would have been higher if competition with buffalo and predation by dingoes were absent. Dingoes did not cause higher pig mortality as pig abundance increased.

Evidence from other regions of Australia (Newsome and Coman 1989, Newsome 1990, Pech et al. 1992) indicates that predation alone can significantly curb prey populations only when prey numbers are initially depressed by a widespread environmental event such as drought in arid rangelands or intense wildfire in temperate forests. The theory is that prey are trapped in a 'predator pit' (Walker and Noy-Meir 1982) where there are too few animals successfully breeding for births to exceed off-take by predation. At the same time, the extra food that such circumstances usually provide allows the predators to survive. For example, in arid central Australia, cattle carrion enabled dingoes to survive droughts and subsequently to concentrate on red kangaroos and perhaps regulate their population after a drought. However, in tropical regions of Australia, with the absence of prolonged droughts or other circumstances to simultaneously reduce populations of main prey, it is unlikely that dingoes could ever limit feral pig populations to low levels.

3.7 Interactions between humans and wild dogs

There are few records of dingoes attacking or killing Aboriginal people, either in camps or in the wild but such incidents are not likely to be reported. There are more reports of dingo attacks on non-Aboriginal people but most are anecdotal (Savant 1969). During the Royal Commission into the Disappearance of Azaria Chamberlain, evidence was presented on the deaths of five children caused by dingo attacks and several other dingo attacks on children and adults throughout Australia over the past 50 years or so (Morling 1987).

'Aggressive behaviour is apparently most common during the dingo's breeding season.'

In recent years, dingoes have become a major tourist attraction at sites in outback Australia and Fraser Island in particular. Consequently, many visitors and residents have deliberately or inadvertently fed dingoes to encourage contact for close viewing and photographs. This has led to many dingoes and other wild dogs losing their fear of people and occasionally displaying aggression towards people, especially at commonly used areas such as camping grounds and picnic areas. Aggressive behaviour is apparently most common during the dingo's breeding season. This provision of food for wild dogs by people and the resulting change in wild dog behaviour has been documented on Fraser Island by Marsterson (1994); Moussalli (1994); Price (1994) and Twyford (1994a,1994b). Current management of this problem is addressed in Section 5.3.2.

Wild dog territories that are centred on areas of high human activity, such as townships, town refuge dumps, camping grounds, picnic areas and resorts, appear to be smaller in size but have relatively higher numbers of wild dogs per pack compared to wild dogs that rely on natural prey in bush areas (Corbett 1998). The nature, frequency and intensity of interactions with people are likely to vary depending on the age and sex of wild dogs, pack size and composition, time of year, supplementary natural food supplies and human reactions to wild dogs. Types of wild dog–human interactions include wild dogs stealing and soliciting food, wild dogs stalking and harassing (nipping, 'playful' biting) humans and outright attacks.

Similar human–predator interactions (involving coyotes (*Canis latrans*) or bears (*Ursus* spp.)) have been recorded in North America (Howell 1982; Carbyn 1989). There appear to be many parallels in the case of the coyote (the ecological equivalent of the dingo in North America) where many attacks are directed towards young human females, with a baby being killed in one instance (Carbyn 1989).

Interactions between humans and wild dogs may occur for other reasons. These include:

- Wild dogs regarding humans as competitors or intruders into wild dog domains and thus defending oestrous females, pups and 'hunting' areas (garbage sites, camp sites, barbecue areas, beaches).
- Wild dogs (mainly adults) regarding humans (mainly children) as prey.
- Juvenile and subadult wild dogs 'playing' with humans.

In relation to the latter example, it is likely that in places such as Fraser Island and Uluṟu, many generations of dingoes have been reared in the close presence of humans (imprinting) so many young dingoes engage in what appears to be 'playful' behaviour. These are normally directed towards other dingoes. In reality, the dingoes are practising behaviours that will be vital for their survival in later life such as nipping and biting to assess the vulnerability of prey (to avoid serious injury to themselves) or to achieve dominance amongst litter mates. Humans, especially children, naturally do not understand this and are most likely to turn and flee (often shrieking) which generally will stimulate chasing and further aggression from dingoes.