The effects of domestic dogs (*Canis familiaris*) as a disturbance agent on the natural environment

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Statement of originality

This thesis contains no material which has been accepted for a degree or diploma by the University or any other institution. To the best of my knowledge and belief, this thesis contains no material previously published or written by another person except where due acknowledgement is made in the text.

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Abstract

This study assesses the impact of domestic dogs on the natural environment. The principal issue investigated is that of disturbance and the consequences for native wildlife, particularly vertebrate species. In addition to the catastrophic effects of killing, maiming and orphaning of wildlife; disturbance can contribute to energetic loss through premature flight or reduced feed intake and reproductive disruption due to nest disturbance. Dogs have been implicated in disease transmission to native wildlife; with faecal contamination of waterways having potential negative affects for marine mammal health. Hybridisation with other canid species is also an issue of concern, as is expropriation of land for the production of food for pet dogs.

The study commences with an overview of ecological disturbance. The literature review then assesses the role of domestic dogs in ecological disturbance, public attitudes towards compliance with dog management legislation and the remediation and mitigation of disturbance by dogs.

Data obtained from the Resource Management and Conservation section of the Tasmanian Department of Department of Primary Industries, Parks, Water and Environment regarding native wildlife presenting for care was analysed in order to determine the principal reported causes of death and injury to native wildlife in Tasmania. These results were then compared with data from the Australian Wildlife Health Centre - Wildlife Hospital at Healesville Sanctuary in Victoria and the data submitted by Tasmanian veterinarians through a three month diary of wildlife presentations recorded by ten practices.

The data is indicative of domestic dogs having a more deleterious effect than domestic cats on native wildlife in Tasmania; particularly in urban and suburban areas and on beaches.

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Chapter 1 Introduction

Purpose of study

The question this thesis sets out to investigate is, "*What are the effects of domestic dogs* (Canis familiaris) *as a disturbance agent on the natural environment?"*

The principal aim of this thesis is to obtain and present evidence of disturbance of the natural environment by domestic dogs (*Canis familiaris*) in order to better inform the public policy deliberations of all tiers of government, but particularly local government, when considering legislation and regulations regarding dog control and management. This study is also, in part, in response to the Hobart Dog Walking Association's (2008) statement that "*Exclusions or restriction* [of dogs] *should be supported by evidenced-based and site-specific reasoning."*

Domestic and feral cats (*Felis catus*) have traditionally been the bête noire regarding the hunting and killing of smaller vertebrate species, particularly birds and mammals. However, this writer's observation of, and reflection upon, the behaviour of his own dogs in the natural environment over many years indicated that dogs may have a more significant detrimental effect upon the natural environment than most people are aware of, particularly near beaches and isolated, fragmented urban natural areas. This suspicion has been enhanced by the discovery of several dead bandicoots, mainly eastern barred (*Perameles gunnii),* but also southern brown (*Isoodon obesulus*) in Poimena Reserve in Austins Ferry, Tasmania. A veterinary pathologist, (Obendorf,

pers. com. various dates) has confirmed many of these deaths were probably due to dog attacks.

Furthermore, several authors have commented upon the relatively few comprehensive investigations into the effects of disturbance by domestic dogs (*Canis familiaris*) on the natural environment. These include Wandeler et al, (1993); Veitch, (2002); Brickner, (2003); Manor and Saltz, (2004); whilst Lenth et al (2006) stated that little was known about dogs' interactions with wildlife.

A survey of residents of country towns and urban edges in NSW by Woolcott et al (2002) regarding their attitudes, behaviour, beliefs, and knowledge regarding urban wildlife renewal found that 62% agreed strongly that cats were a real threat to wildlife, but only 26% believed dogs were. A more recent online, non randomised, survey of Blue Mountains City Council residents gave similar results (Henson, pers. com, 2011). Cats were again considered by residents to be a significant threat to wildlife – 91.5% if allowed to roam outside at night, 90.2% if straying into bushland reserves and 75.6% if allowed to roam outside during the day. Slightly fewer people considered domestic dogs to be a threat to wildlife – 87.3% if straying into bushland reserves, 71.3% if off leash in bushland reserves. However, only 23.5% considered on leash dogs to be a significant threat to wildlife in bushland reserves.

Not all studies appeared to recognise the potential for dogs as a disturbance agent. For example Smith and Quin (1996) discussed the decline and extinction of conilurine rodents in Australia; and Wilson and Friend (1999) canvassed the responses of Australian mammals to disturbance. When

discussing predation, these authors referred to foxes (*Vulpes vulpes*), cats (*Felis catus*) and the dingo (*Canis lupus dingo*), but overlooked the domestic dog as a possible cause.

Similarly, Dowding and Murphy (2001) assessed the predation impacts of introduced mammals on New Zealand's endemic shorebirds and stated that predators were a disproportionate cause, compared with other locations where habitat destruction is the primary impact. They mentioned that New Zealand species are predator naïve, and reported that cats, ferrets, stoats, rats, hedgehogs and brush-tailed possums were the major predators – but did not mention domestic dogs. This is despite the widely reported killing of kiwi by domestic dogs, for example that of a single dog killing 500 kiwis from a population of 900 over several weeks, (Taborsky, 1988; Diamond, 1989; McLennan and Potter; 1992; McLennen et al., 1996). Indeed, McLennan et al (1996) claimed that dogs and ferrets were major predators of kiwi.

This dissertation commences with a brief look at the definitions of disturbance, the types of disturbance and its consequences before progressing to the specific issue of disturbance by domestic dogs, the attitudes of dog owners towards native wildlife and dog control regulations and closes with a range of mitigation options which include education, enforcement and planning procedures.

A key feature is an analysis of native wildlife presenting to the Resource Management and Conservation Service section of DPIPWE, Tasmania in order to assess the cause(s) of injury and death of specimens.

Chapter 2 Disturbance

For the purpose of this study, the definition proposed by Wilson and Friend (1999: 87) that defined disturbance as implying "*an unusual event that upsets normality, or the due course of processes*" although they stated that some disturbances in ecological communities were frequent and not unusual, others may be "*rare and catastrophic*".

It seems logical to classify disturbance as being either natural extraterrestrial, natural terrestrial or anthropogenic; whilst recognising that some disturbance may be a combination of anthropogenic and natural causes. Some bushfires and flooding fall into this category.

2.1 Natural extraterrestrial disturbance

Numerous rocky bodies, mostly displaced from the asteroid belt between Mars and Jupiter, and comets mostly originating from the Oort Cloud at the outer edge of the solar system, cross Earth's orbit. These have infrequently collided with Earth, playing an important role in the evolution of life on the planet, including the likely delivery of water to a cooling earth.

The consequences of the Chicxulub asteroid impact at the end of the Cretaceous era ~ 65 million years ago, included the mass extinction of entire groups such as dinosaurs (except birds), many marine and flying reptiles and ammonites (Schulte et al 2010). There was also considerable species level extinction in other groups. The probable cause of the 1908 Tunguska impact over Siberia was a portion of Comet Encke (Kresak, 1978). This view was supported by Kelley et al (2009), who concluded that water vapour visible in the night sky visible from London immediately after the event indicated that

this was caused by a comet. Supernovae were also identified as a potentially catastrophic disturbance agent by Hartmann et al (2002), who considered such an episode could have been responsible for the dinosaur extinction at the end of the Cretaceous era ~ 65 million years ago.

2.2 Natural – terrestrial disturbance

The outer portion of Planet Earth is still very active. Convection currents in the mantle drive the motion of large plates at the surface. These manifest as continental drift, which serves to maintain a steady supply of volcanic activity, earthquakes and the resulting tsunamis; as experienced within the first few months of 2011 in Japan and New Zealand. These events result in varying levels of disturbance to flora and fauna, especially near coastlines (Clarkson, 1990; del Moral and Wood, 1993; Fridriksson, 1987 and Williams et al, 2010).

2.3 Other natural disturbance agents

The planet has always been subjected to different climate regimes, glacial epochs and interglacials, storms, bushfires and floods since it developed an atmosphere. Disturbance has played a role in the development of early human civilisation. For example, the annual Nile floods in ancient Egypt maintained the fertility of the delta and floodplain which enabled the rise of the civilisation that flourished there from 3,000 BC till around the time of Christ (Allen, 1997).

2.4 Anthropogenic climate change

Anthropogenic climate change is predicted to result in drastic disturbance to the natural environment, possibly disrupting reproductive cycles, migration characteristics and destroying the synchronicity between the arrival of young with the peak production of food (McCarty, 2001). An example of the latter is

the hatching of birds to coincide with that of caterpillars, as recorded by Buse et al. (1999).

2.5 Other anthropogenic disturbance agencies

There is a whole litany of anthropogenic disturbance agencies cited in the literature, with motor vehicles, (Boyle and Samson, 1985; Pfister et al, 1992; Donefer, 2003; Ben-Ami et al 2006 and Manusu, 2011) and low-flying aircraft heading the list, (Owens 1977; Henry, 1980; Campredon, P. 1981; Safina and Burger, 1983; Smit and Visser, 1993 and Rogers et al, 2006). These included off road vehicles, helicopters and ultra-light aircraft. Other motorised causes of disturbance were people in cars (Klein et al, 1995), and snowmobiles (Boyle and Samson, 1985). Owens (1977) identified small boats with outboards, whilst Boyle & Samson (1985) found boats in general to be a disturbance. Even kayaks were implicated by Smit and Visser (1993).

Other sources of disturbance included horse riders (Owens 1973); mountain bikes (Taylor and Knight 2003); hikers and walkers (Owens, 1977; Boyle & Samson, 1985; Smit and Visser, 1993 and Taylor and Knight, 2003); Kites, which were seen as birds of prey, (Bryant and Caouette, 2011); photographers (Bryant and Caouette, 2011 and Klein 1993); biologists (Safina and Burger 1983). Unsurprisingly, kite buggies on beaches (Thomas et al 2003); windblown litter (Rogers et al 1996); fireworks (Manusu, 2011) and shooters (Henry, 1980) were also implicated.

2.6 Consequences of disturbance to the natural environment

Several studies have considered the consequences of disturbance to wildlife. These consequences include:

- direct mortality, with immediate on-site death; (Boyle and Samson, 1985; Pomerantz et al, 1988; Ebenhard, 1998)
- indirect mortality (eventual, untimely death caused by predisposing disturbance event); (Pomerantz et al, 1988)
- lowered productivity (reduced conception, nesting and juvenile survival rates), (Pomerantz et al, 1988; Lima, 1998)
- reduced use of refuge; (Pomerantz et al, 1988)
- reduced use of preferred habitat in refuge; (Pomerantz et al, 1988; Lima, 1998)
- aberrant behaviour or stress (less food, which affects weight gain, results in poorer reproduction rates, and affects migration ability); (Geist, 1979; Pomerantz et al, 1988).

Other effects listed by Ebenhard (1988) that introduced animals may have in an area, included modification of vegetation types, competition for resources, transmission of parasites and diseases and hybridisation with native wildlife.

Nonlethal effects of disturbance can be masked by the often dramatic effects of lethal predation (Lima, 1998), possibly resulting from the prey species modifying their behaviour in response to the threat of predation; whilst Geist (1979, 5) noted that "… *if an animal is excessively aroused … the added cost of excitement may interfere with health, growth and reproductive fitness*."

Examples included increased risk-taking if deprived of food, as many bird species which prefer to stay close to vegetative cover are forced to forage in more open areas (Lima, 1998). For example, Caraco et al (1980) found that the

scanning times for danger by members of a flock of Yellow-eyed Juncos (*Junco phaeonotus*) increased with distance from cover; thereby reducing foraging effectiveness.

Shorebirds are at particular risk from disturbance, due to their habit of nesting on open beaches with little or no cover. Lafferty et al (2006) suggested a number of consequences relating to shorebird disturbance, including exposing nests, suspending foraging, expending energy on flight and gaining insufficient condition for migration. Similarly, Spruzen et al (2006) stated that any disturbance of shorebirds whilst nesting, feeding or roosting was a significant threat. Consequences included wasted energy due to unnecessary flight, reduced food consumption, disrupted incubation and chick care, and predation of unattended chicks.

Larger animal species generally became alert to human disturbance earlier than smaller ones (Blumstein et al, 2005), and it was reported by Blumstein et al (2005) that food quantity consumed and other fitness-related issues were affected by the distance at which animals detected humans.

2.6.1 Reduced/increased numbers/presence

Several studies have found that the presence of humans resulted in a decreased presence of some native wildlife species near tracks and trails, whilst other species became more common (Bolger et al, 1997; Miller et al, 1998; Taylor and Knight, 2003). This may have been the result of an actual decline in total numbers for that species, or because individuals have moved elsewhere, possibly to a less suitable foraging or nesting area. This supports personal observations in Poimena Reserve in Austins Ferry, Tasmania. Aggressive

noisy miners (*Manorina melanocephala*) have taken over the parkland areas in recent years, to the apparent detriment of species such as the scarlet robin (*Petroica multicolor*) and dusky wood swallow (*Artamus cyanopterus*).

2.6.2 Foraging disruption

An animal's ability to forage is essential to its capacity to maintain condition in order to be able to migrate, reproduce or survive adverse weather conditions that reduce the availability of food. Studies have shown that disturbance disrupts the ability of wildlife, particularly shorebirds and geese, to forage at their full potential, (Fredrickson and Drobney, 1979; Burger, 1986; Pfister et al, 1992; Smit and Visser, 1993; Brown et al, 2000b and Lafferty, 2001).

Human disturbance reduced foraging time and increased running and crouching time, indicating likely stress levels with possible reduced reproductive success (Burger 1991); whilst disturbance affected the arrival and departure times of waders and reduced potential feeding times (Fitzpatrick and Bouchez, 1998). Disturbances of three minutes per hour represented 5% of the available feeding time at low tide on the beach being studied. They considered that this loss may be compensated for by reducing resting and preening times. Neither compensatory behaviour is desirable as a bird's health and fitness depend upon getting sufficient rest and maintaining their plumage in top condition.

Several studies have investigated disturbance in geese and found that it disrupted feeding, resulting in loss of body weight with potential consequences for migration or reproduction: (Owen, 1972; Henry,1980; Bélanger and Bédard, 1990; Madsen, 1995; and Gill et al, 1996).

A study by Stalmaster and Newman (1978) into the effects of disturbance on wintering bald eagles (*Haliaeetus leucocephalus*) in Washington State, USA found that there were fewer eagles in areas of high human activity, and more in areas subjected to less disturbance. Feeding was particularly badly affected by human activity, with birds leaving the feeding area for several hours.

2.6.3 Energetic loss

The corollary to insufficient energy consumption due to disturbance induced flight is the additional use of energy by flight from disturbance; a lose-lose scenario. Many animals responded to disturbance by energetic loss through flight, and decreased foraging time; avoiding a part of their normal range due to disturbance (Taylor and Knight 2003).

Several studies have investigated the energy consumption of birds when taking flight from disturbance, for example Rogers et al. (2006) stated that flight is costly in energy consumption for birds. They cited the example of a lean Great Knot (*Calidris tenuirostris*), where a large bivalve would provide about 2.77 KJ. This would give the Great Knot sufficient energy for six hours of sleep, 159 minutes of foraging time, steady flight for 26 minutes, but only 7.5 minutes of alarm induced short flight involving take off, climbing and higher speed flight than usual. Similar conclusions were drawn by Nudds and Bryant (2000) in their study of Zebra finches (*Taeniopygia guttata*) and by Hambly et al (2004) who compared the energetic flight costs of the Palestine sunbird (*Nectarinia osea*) with those of the Starling (*Sturnus vulgaris*).

2.6.4 Nest disturbance

Given that the ultimate purpose of a life-form is to pass on its genes to the next generation, the ability to reproduce successfully and raise fit, healthy young is the ultimate goal. Therefore, any disturbance that disrupts this activity is a possible threat to that individual's ability to pass on its genes. Rodgers and Smith (1995, 89) stated that reproductive success is reduced by '… *egg and nestling mortality, nest evacuation, … reduced nesting body mass and slower growth, premature fledging and modified adult behaviours'.*

Mortality of Snowy plover (*Charadrius alexandrinus*) chicks increased at weekends and on public holidays, with increased human visitation to the nesting area according to Ruhlen et al. (2003). Strauss and Dane (1989:42a**)** noted that "[Piping] *Plovers nesting in the disturbed section of the beach also had lower hatching and fledging rates, as well as higher rates of predation and territory abandonment than did plovers nesting in the undisturbed section of the beach. In addition, chicks altered their foraging behaviour during periods of heavy human disturbance.*"

Cornelius et al (2001) found that increased human presence close to marine bird assemblages resulted in an increase in birds moving to a reserve in order to roost. However, people seemed to hold a lesser degree of disturbance for the same birds when the birds were foraging.

Human activity could cause brood movement resulting in chicks becoming separated, with movement into less satisfactory territory possibly reducing available food or shelter, and provoking defensive responses from others in the new territory (Ruhlen et al. 2003). This would clearly, in turn, create a flow on disturbance to occupants in the new areas.

2.6.5 Eggs being chilled or over-heated

Egg temperature is critical to embryo development and survival, with several studies finding the possibility of eggs being chilled or over-heated, depending upon ambient temperature and nest location, is a major consequence of disturbance. (Huggins, 1941; White and Kinney, 1974; Olsen and Baker, 2001; Lyons, 2003; Pendlebury and Bryant, 2005; Olson et al, 2006; AlRashidi et al, 2010 and Birds Australia, 2010).

These studies indicated that if an incubating bird is disturbed sufficiently often, the developing young may be placed at jeopardy. Possible consequences included mortality, or reduced chick size affecting reproductive potential and predation of eggs or chicks.

Chapter 3 Disturbance by dogs

3.1 Introduction

Before discussing ecological disturbances by domestic dogs, it is necessary to define what is meant by the term '*domestic dog*'. Several authors have differentiated between domestic, free-ranging and feral dogs, with Veitch (2002) summarising the situation regarding feral dogs globally for the New Zealand Endangered Species Recovery Council. Dogs were categorised as being either domestic, human-dependent, free-ranging or feral, whereas Brickner (2003) classified dogs as being either domestic, stray or feral, whilst Galetti & Sazima (2006: 146) defined feral animals as domestic "*... living in a wild state with no food or shelter provided by humans and showing avoidance to human contact"*. Berman and Dunbar (1983) pointed out that free-ranging dogs have food provided by their owners, so do not spend energy on hunting or foraging, but they suggested that these dogs are motivated by curiosity, or habit.

Howard & Marsh (1984), in Veitch (2002: 3), "*... concluded that the majority of cases* (of wildlife predation*) involved unrestrained owned dogs and were the result of both overpopulation of pet dogs and owner irresponsibility*". Personal observation supports this conclusion, which should include dogs accompanied by guardians, but not under close control.

3.2 Disturbance types

The literature cites an extensive range of disturbance effects of domestic dogs upon the natural environment. These include:

- killing or physical injury (Taborsky, 1988; Diamond, 1989: Fuller, 1990; Doncaster, 1994; Shine and Koenig, 2001)
- chasing (Lowry and McArthur, 1978; Causey and Cude, 1978; Sime, 1999; Lenth et al, 2006; Berry, 2011)
- flushing of birds (Mitchell et al. 1988; Fernandez-Juricic and Telluria, 2000, Lafferty, 2001)
- reduced numbers and species (Banks and Bryant, 2007)
- avoidance, either temporally or spatially (Daniels, 2011)
- increased heart rates of mountain sheep (*Ovis canadensis canadensis*) (MacArthur et al. 1982)
- increased vigilance of Eurasian coots (*Fulica atra*) when a recording of a barking dog was played (Randler 2006)
- nest disturbance (Govan, 1998; Gutzwiller et al, 1998)
- energetic loss / increased vigilance / lost foraging opportunities (Burger, 1986; Fernandez-Juricic and Telluria, 2000)
- introduced disease (Ebenhard 1988; Pain, 1997; Laurenson et al, 1998; Hall and Schulte, 1999; Sime, 1999; Lenth et al, 2006; Galetti & Sazima, 2006; Stolen, 2011)
- hybridisation with native canids, such as dingos (*Canis lupus dingo*) (Newsome and Corbett, 1982; Fleming et al., 2001)
- vegetation modification (Galetti & Sazima, 2006; Larson and Gallie, 2010)

- the use of agricultural land to produce pet food (Coppinger and Coppinger, 2001), and
- the packaging and transport of pet foods to the marketplace (Lonsdale, 2005).

3.3 Predation

3.3.1 Predisposing causes of predation

Dogs have been implicated in attacks on native animals over a period of time, typically as a result of land clearance opening up vegetation and forcing species into the open in order to move between locations. Examples include koalas (*Phascolarctos cinereus*) (Lunney et al, 2007), cassowaries (*Casuarius casuarius*), (Larson and Gallie, 2010) and Lumholtz's tree-kangaroos (*Dendrlagus lumholtzi*), (Newell, 1999).

Predation by dogs was shown by Lunney et al (2007) to be a significant cause of mortality for koalas at Port Stephens, N.S.W., accounting for 10 out of 23 recorded deaths (43%). Whilst fire management was an important factor in koala population survival, it was shown that habitat fragmentation was leading to koala population decline through predation by roving dogs.

The Mission Beach region in Queensland's wet tropics is becoming increasingly fragmented, due to coastal development, resulting in cassowaries having to cross roads and open ground when travelling between patches (Larson and Gallie, 2010); leaving them at risk from dog predation and vehicles. Dogs or dingoes killed at least four of six Lumholtz's tree-kangaroos (*Dendrolagus lumholtzi*) in an area of recently cleared rainforest in northern Queensland. This was considered to be a result of the clearing, as there were

no reported deaths in surrounding, uncleared areas and in the cleared areas prior to clearing (Newell, 1999). Bandicoot population decline on the mainland of Australia has also been attributed to land clearance, and Hocking (1990) stated this is a risk to Tasmanian bandicoot populations.

These findings point to the likelihood of a significant predation risk to native species in suburban and peri-urban areas from unrestrained domestic dogs.

3.3.2 Methodology for determining species being predated

Methods used to determine the responsibility of a dog or dogs for wildlife predation include direct observation, assessment of injuries by a veterinarian, examination of stomach contents and faecal analysis. However Ebenhard (1988) pointed out that some rare species may not be observed in predator's stomach contents simply because they are so rare. He also cautioned that predators may not have killed whatever is in their stomach, but may have scavenged the body.

Consequences of predation may be catastrophic for some species, or a particular colony or population, if that species is considered to be at risk or endangered. For example, a single dog was responsible for killing 500 north island brown kiwis (*Apteryx australis mantelli)* from a colony of about 900 over a few weeks in New Zealand (Taborski, 1988; Diamond, 1989). Five dogs destroyed the largest flamingo (*Phoenicopterus roseus*) colony in Italy at Cagkiari in Sardinia in one day, (Genovesi and Duprae, n.d., in Brickner, 2003), and Webb (2009) reported that dogs were thought to have been responsible for the deaths of 30 little penguins (*Eudyptula minor*) at a West Ulverstone beach in Tasmania on the 31 December 2008. Brickner (2003)

cited a 1998 Colorado Wildlife Report which stated two dogs killed 12 elk (*Cervus canadensis*) in one day.

Hammersley (personal communication, 2011) provided records for native wildlife presenting to the Healesville Sanctuary Veterinary Hospital over the period from 20 October 2008 to 31 January 2010. The data covered wildlife presenting as a result of injury by other animals, and predator was sorted as either cat, dog, fox or other unknown animal. Dogs were credited with more admissions than cats, with 36 birds, 37 mammals and 48 reptiles; whilst cats accounted for 45 Birds, 36 mammals and 6 reptiles. The attacks by unknown animals accounted for six birds, seven mammals and four reptiles.

3.3.3 Scat analysis

Brunner (personal communication, 2010) analysed the contents of 24 dog scats taken from The Pines, a 238 hectare reserve about 40 kilometres south east of Melbourne. The scats contained sources of rabbit (8), wallaby spp. (4), bandicoot spp.(4), brush-tail possum (3), ring-tail possum (3) and swamp rat (2). Brunner stated that there had been a dramatic decline in bandicoot, swamp rat and other species since Parks Victoria took control of the area from the Dept. of Agriculture and Rural Affairs. Some of this decline was considered to be due to the provision of gates to enable entry of visitors with dogs.

An analysis of scats from dogs and foxes (*Vulpes vulpes*) from coastal forests near Bega in NSW found that both predators had similar diets, confirming previous studies that they are both opportunistic hunters and scavengers (Lunney et al, 1990). Mammals were strongly represented – with 91% of scats containing hair from mammals. Twenty four of these were native species.

Dogs were more strongly implicated in the consumption of larger species – *Wallabia bicolour, Macropus rufogriseus* and *Vombatus ursinus.* They commented that many farm dogs frequented the area and suggested that forest logging may have made macropods more susceptible due to loss of cover and road kill.

Triggs et al (1984) analysed scats from foxes (937), dogs (412) and cats (48) in the Croajingalong National Park in SE Victoria, Australia. Dogs were found to have eaten ringtail possums (*Pseudocheirus peregrinus*) (38%) two wallaby species *Macropus rufogriseus* and *Wallabia bicolor,* (34%), wombat (*Vombatus ursinus* (11%), *Antechinus* species (11%), *Rattus* species (10%) and Echidna (*Tachyglossus aculeatus* (5%). *Wallabia bicolor* was the predominant species in dog scats in the Beecroft Peninsula, with *P .pergrinus, O. cuniculus, R. rattus* and *Tachglossus aculeatus* being equally represented (Meek and Triggs, 1998); and Barnett and Rudd (1983) found juvenile sea lion (*Zalophus californicus*) and fur seal (*Arctocephalus australis*) were in 8% of dog scats from the Galapogos.

3.3.4 Predation on mammals

Several North American studies have investigated the relationship between dogs and deer: Ballard et al (1999), Causey and Cude (1980), Progulske and Baskett (1958), Scott and Causey (1973), Lowry and McArthur (1978). These studies produced conflicting conclusions, with those of Scott and Causey (1973) and Causey and Cude (1978) finding little evidence of dogs predating upon deer, although Causey and Cude (1978: 483.) stated that dogs regularly chased White-tailed deer (*Odocoileus virginianus*) in Alabama – concluding that dogs "*... are hardly more than a nuisance to adult white-tailed deer"*.

They did not seem to consider that a doe being pursued could loose a fawn she was carrying, although they conceded that further study of possible fawn predation by dogs was needed.

Similarly, Progulske and Baskett (1958) studied the harassment of white-tailed deer (*Odocoileus virginianus*) by owned dogs in Missouri. They concluded that few deer were killed by dogs, even though they were often seen chasing them. There were only three reported deaths of deer from dog attack over 6½ years. However, unlike Causey and Cude (1988), they noted that they were unable to evaluate the possibly serious effects of deer harassment by dogs. Ballard et al (1999) found that Domestic dogs killed three white-tailed deer (*Odocoileus virginianus*) fawns during a study in New Brunswick. This compared with coyotes (*Canis latrans*) killing nine deer, black bears (*Ursus americanus*) killing five, and bobcats (*Felis rufus*) killing two over the same period.

Lowry and McArthur, (1978) reported multiple dog attacks on deer in northern Idaho, USA as recorded by a conservation officer with the Idaho Fish and Game Department. Twelve of 39 deer chased by dogs died as a result. Eight deer were killed outright, one was chased into a river and drowned and three deer were crippled and had to be shot by a conservation officer. It was not stated whether any loss of fawns was recorded as a result of these deaths. Free-roaming dogs in fragmented areas in Israel were found by Manor and Saltz (2004) to be a major reason for the poor ratio of kids to does in the gazelle population. This ratio improved after a cull of dogs.

Dogs reportedly killed adult eastern barred bandicoots (*Perameles gunnii*), (Mallick et al, 1997) in Tasmania. Whilst the incidence is relatively low, at

about seven or eight per dog lifetime, they considered this could threaten bandicoot populations in fragmented habitat; a view supported by Hocking (1990), who stated that dogs were a bandicoot predator in suburban areas and farmland. Several dead bandicoots (*Perameles gunnii* and *Isoodon obesulus*) found in the Poimena Reserve in Austins Ferry, Tasmania, were probably victims of dog attacks, according to Obendorf (pers. com., various dates).

The main reasons for agile wallabies (*Macropus agilis*) presenting at vets were dog attacks and vehicles (Olsson, 2010), whilst Ben-Ami et al (2006) reported that swamp wallabies (*Wallabia bicolor*) were the preferred diet of feral and domestic dogs in Muogamarra Nature reserve north of Sydney.

Of 25 koalas (*Phascolarctos cinereus*) recorded killed between 1947 and 1989 in Barrenjoey Peninsula in the Warringah Shire north of Sydney, NSW six of these deaths (24%) were attributed to dog attacks in a 1989 survey of residents. However, on Phillip Island, Victoria, only 6% of koala deaths were attributed to domestic dogs, with motor vehicles causing about 60% (Smith and Smith, 1990).

Mammals comprised 75% of all vertebrate species killed by feral dogs at the Santa Genebra Reserve in S.E. Brazil; suggesting that feral dogs were the main reason for extinction of paca (*Cuniculus* sp.), brocket deer (*Mazama* spp.) and Azara's agouti (*Dasyprocta azarae*) in the reserve (Galetti & Sazima, 2006). These extinctions could disturb seed dispersal of local plants, which have flow on consequences for forest vegetation structure. Similarly, Silva-Rodríguez and Sieving (2011) stated that one of the most frequent causes of death in the Chilean pudu (*Pudu puda*), the world's smallest deer, was dog attacks.

3.3.5 Predation on birds

Flightless and ground nesting bird species, such as cassowaries (*Casuarius casuarius*) reported by Larson and Gallie (2010), and kiwis are particularly vulnerable to dog attacks. McLennen et al. (1996) found that between 5% and 16% of adult kiwis were killed by predators, with dogs and ferrets as the principal culprits. The New Zealand Department of Conservation website detailed the destruction of kiwis by dogs:

> *"…- between 1990 and 1995 dogs caused 135 (70%) of 194 kiwi deaths reported in Northland. Pet dogs accounted for 29 of those, feral or wandering/stray dogs 38 and significant numbers of others were reported involving farm, pig/goat hunting dogs and a duck shooter's dog which killed at least five birds. Deaths caused by pets included dogs being taken for daytime walks and dogs not tied up at night, at home or camping. …*"

Little Penguins are at particular risk of predation by cats, dogs and foxes during the period August to February in Tasmania when they come ashore to breed and also during the annual moulting period. The young are particularly vulnerable when they are left behind in their burrows when the parents go fishing, as they sometimes leave the safety of their burrows. Dog attacks on Penguin colonies are recorded for both the Derwent Estuary and north-west coast of Tasmania and the scent from a dog in a penguin colony can attract other dogs (The Derwent Estuary Program, 2009).

Dogs were thought to have been responsible for the deaths of 30 little penguins at a West Ulverstone beach on the 31 December 2008 (Webb, 2009); whilst Harrigan (1992) found that predation and road traffic were the major causes of

little penguin deaths in Victoria, citing a case where six adults were found dead near Warrnambool with bite marks consistent with dog or fox attacks.

Little penguin colonies have been considerably reduced since the arrival of Europeans; four of 12 little penguin (*Eudyptula minor*) colonies investigated in south-eastern Tasmania had disappeared, with a noticeable size reduction in another two over the previous decade. Several possible causes were considered, including domestic dogs, (Stevenson and Woehler 2007).

Only one little penguin colony on Phillip Island (Vic.) still survived, from the ten colonies recorded in the late 1800s (Dann, 1992). This surviving colony was considerably smaller than previously recorded. Dogs were responsible for 15.4% of the deaths of banded adults on Phillip Island, and foxes (*Vulpes vulpes*) for 57.7%. It was also considered that dogs and foxes were a factor in the decline in little penguin numbers on the Australian mainland and offshore islands.

Galápagos penguin (*Spheniscus mendiculus*) accounted for 32 % of species in dog faeces on the Galapogos, with Audubon shearwater (*Puffinus lherminieri*) 7%, pelican (*Pelicanis occidentalis)* 7% and blue-footed booby (*Sula nebouxi)*, 6% in a study by Barnett and Rudd (1983). Dogs have reportedly killed 60 cassowaries in the period between 1992 and 2010, the same number as killed by cars, in the Mission Beach area of Queensland's wet tropics (Larson and Gallie, 2010).

3.3.6 Predation on reptiles

One could possibly consider reptiles to be at particular risk from dog attack, due to their need to warm up before becoming fully active. On Santa Cruz and

Isabela islands, in the Galapagos, 58% of dog faeces contained marine iguana (*Amblyrhynchus cristatus*), with the species being the main content for 51% of dog faeces (Kruuk and Snell, 1981). In the main study area 92% of dog faeces contained iguana remains. Other prey being sea lion, fur seal, birds and feral ungulates. In addition to killing about 275 of the marine iguana population (mostly adults) annually, the dogs also dug up and ate their eggs. The authors concluded that this rate of predation was unsustainable. Marine iguana (*Amblyrhynchus cristatus*) remains were found in 35% of dog scats from the Galapagos, in an analysis of 169 dog faeces and 12 stomach contents by Barnett and Rudd (1983).

Feral dog packs in southeast Alabama were observed killing an adult gopher tortoise (*Gopherus polyphemus*) and were probably responsible for digging out several tortoises from their holes, as reported by Causey and Cude (1978). The species is regarded as being threatened in parts of its range.

In Australia, Heard et al, 2006, studied the predation by canids on the inland carpet python (*Morelia spilota metcalfei*) in Victoria. Whilst they found foxes to be the principal threat, they also considered domestic dogs to be a potential problem.

Records of bluetongue lizards (*Tiliqua scincoides*) presenting for care at the New South Wales Wildlife Information and Rescue Service (WIRES) between January 1989 and December 1998 were analysed by Koenig et al (2002), with dog attacks being responsible for the recorded deaths of 42% of the lizards that died.

3.4 Beach disturbance

Several authorities have cited dogs as a major disturbance to threatened or endangered species on beaches; for example western snowy plovers (*Charadrius alexandrinus nivosus*) (Lafferty 2001; Donefer, 2003); hooded plovers (*Thinornis rubricollis*); (Knowler, 2010; Fletcher, 2010); sanderlings' (*Calidris alba*) (Thomas et al, 2003); Peruvian tern (*Sterna lorata*), (Zavalaga et al, 2007; Birdlife International, 2008) and African black oystercatcher (*Haematopus moquini*), (Leseberg et al, 2000).

The most frequently reported disturbance effects of dogs is on beaches where shorebirds are nesting, foraging or roosting and this may be partly due to the better visibility on beaches due to lack of cover. Humans were less likely to disturb snowy plovers than were dogs (Lafferty, 2001); and Burger (1986) found that as shorebird disturbance increased, so too did the number of birds taking flight. An increase in dog numbers led to more birds flying, whilst Spruzen et al (2006) found that dogs were the third largest threat recorded in a study of shorebirds in Tasmania, at 72 locations, after 4x4 drive vehicles and trailbikes (109 locations) and people walking (101 locations). This compared with cats, the sixth most frequent threat, at 34 locations. Berry (2011) reported that a dog he had owned would chase seagulls on the East Devonport beach and had caught at least one.

3.5 Bushland and park disturbance

Several studies have found that the presence of dogs has resulted in reduced native wildlife numbers close to tracks and trails (Andrews, 1991; Fernández-

Juricic. and Telleria, 2000; George and Crooks, 2006; Lenth et al, 2006; Banks and Bryant, 2007; Lenth and Knight, 2008).

Walking dogs in bushland resulted in a reduction of up to 35% in diversity of bird species, whilst abundance of birds was reduced by 41%, in a study by Banks and Bryant (2007); with ground-nesting birds being particularly subject to disturbance.

Lenth et al (2006) found that Mule deer (*Odocoileus hemionus*) in Colorado were found in 'significantly' lower numbers near trails where dogs were permitted than in areas where dogs were not allowed. Small mammals such as chipmunks (*Eutamias* spp.), mice (*Peromyscus* spp.), prairie dogs (*Cynomys* spp.), rabbits (*Sylviagus* spp.) and squirrels (*Sciurus* spp.) were less active near trails where dogs were permitted. The bobcat (*Felis rufus*) was also less frequently detected near dog permitted trails, but red foxes (*Vulpes vulpes*) were detected more often – possibly in response to dogs' territory marking with urine and faeces.

Similarly, Banks and Bryant (2007) found that walking dogs in bushland resulted in a reduction of up to 35% in diversity of bird species, whilst abundance of birds was reduced by 41%. They suggested that even dogs on leash can result in bird displacement, and proposed that dog walkers should not be permitted in sensitive conservation areas. Humans walking without a dog resulted in about half the disturbance effect of a dog being walked on leash. Ground-nesting birds were particularly subject to disturbance.

However, Forrest and St. Clair (2006) presented a contra view in their comparison of the effects of free running versus on leash dog areas in river

valley parks in Edmonton, Alberta, Canada. Their study of the relative abundance and diversity of small mammals and songbirds found no discernable difference; and suggested that "*off-leash dogs have no effect on the diversity or abundance of birds and small mammals in urban parks"* (Forrest and St. Clair (2006: 51).

They recognised that other factors may account for this result, including possible non-compliance with leash laws, wildlife tolerance, and habituation to canines, as wild coyotes are present in study area. They also suggested that off-leash areas may occur in areas of better habitat quality. One factor Forrest and St. Clair (2006) did not appear to consider was the relative size of this park: 7,400 ha. [74 sq. kilometres, or 28.7 sq. miles] compared with smaller, isolated urban/suburban areas. It may be that such a relatively large area has sufficient population of species studied to enable the near track environment to quickly recruit new residents. Of the factors suggested by Forrest and St. Clair (2006) themselves, it is most likely that non-compliance with leash laws is a factor, given the observations of such lack of compliance in other settings (Bekoff and Ickes, 1999; Chester, 2001; Lafferty, 2001; Ruhlen et al, 2003; Williams et al, 2009; Acevedo-Guti´errez et al, 2010; Knowler 2010; Iijima, 2010; Manusu, 2011 and Burns, 2011).

Dogs influenced prairie dog behaviour by making them less prone to disturbance by people without dogs; as a result of dog harassment which made them alert more of the time and less likely to play when dogs were present (Bekoff and Ickes, 1999).

Nesting Golden plovers (*Pluvialis apricariua*) were more easily disturbed by dogs than humans when nesting on moors (Yalden and Yalden, 1990).

Disturbance by humans increased energy expenditure by 15% for the parent birds. Chicks were unable to forage or to be brooded, as they were hiding in response to parental alarm calls due to disturbance. When broods were led to less disturbed areas by their parents, the new neighbours responded with strong territorial defence (Yalden and Yalden, 1990). It could be reasonably expected that this would extend the spatial and temporal extent of the initial disturbance.

3.6 Energetic loss

A number of reports found that feral dogs are not particularly good hunters, with low predation rates (Veitch, 2002; Lenth et al, 2006). However, this does not diminish the energetic loss for individuals who take flight, or the loss of young who may be separated from parents.

Animals depend upon their ability to forage with minimum disturbance in order to maintain condition for breeding, winter or drought survival and migration. Excessive disturbance may result in animals deserting nests, moving to less productive foraging areas or less secure roosting/sleeping areas, or having to keep alert to disturbance instead of feeding. Consequences may include fewer young, lighter young, nest predation, eggs chilling or over-heating, or low weight for migration.

3.7 Disease transmission

3.7.1 General

The significance of introduced diseases and parasites in domestic dogs was under recognised according to Ebenhard (1988), whilst Galetti & Sazima (2006:146) stated that feral dogs "*carry infectious diseases such as toxoplasmosis, sarcosporidiosis and rabies*" and that there is high potential for

infection of crab-eating foxes (*Cerdocyon thous*) with parvovirus and canine distemper.

3.7.2 Disease transmission to terrestrial mammals

Several terrestrial mammal species are known to have contracted diseases from dogs, either by direct contact or through an intermediary. Infection risk from dogs was enhanced by greater density of domestic dogs than wild dogs (Brickner, 2003), which helped to maintain a reservoir of infection in the population.

As could be expected, with their close relationship, wolves (*Canis lupus*) are at major risk from disease transmission from domestic dogs. Examples include wolf pup mortality in Glacier National Park in the 1990s with parvovirus infection (Stolen, 2011) and gray wolves in Yellowstone National Park possibly contracted parvovirus or canine distemper from domestic dogs (Lenth et al 2006). Laurenson et al (1998) considered the threat from canid disease to Ethiopian wolves and concluded that such disease posed a '*significant threat*' to this wolf population; similarly Pain (1997) suggested that the Ethiopian wolf and the African wild dog (*Lycaon pictus*) were at particular risk from canine distemper spread from domestic dogs. The threat to the African wild dog appears to be confirmed by Allexander and Appel (1994), who found that known populations of African wild dogs disappeared from Kenya's Masai Mara in 1991, coinciding with the advent of canine distemper in domestic dogs. Similarly, Gowtage-Sequeira et al (2009) traced an outbreak of canine distemper in black-back jackals (*Canis mesomelas*) in Namibia to domestic dogs.

A canine distemper outbreak killed an estimated one third of lions (*Panthera leo*) in the Serengeti National Park in 1994 (Pain, 1997). This infection was from domestic dogs, possibly through spotted hyenas (*Crocuta crocuta*) as an intermediary.

The marsupial wolf [sic] (*Thylacinus cynocephalus)* may have been the victim of canine distemper according to Pain (1997), who considered other species at risk could include Ethiopian wolves, Blanford's fox, and African wild dogs from rabies – for example in the Masai Mara reserve in Kenya in 1989 and in the Serengeti in1990. The giant otters in Peru are potentially at risk from canine distemper and parvovirus (Pain, 1997), whilst Goltsman (1996) found arctic foxes on the island of Mednyi (*Alopex lagopus semenovi*) had been infected with mange caught from hunters' dogs. Black footed ferrets (*Mustela nigripes*) in North America were also affected by Canine distemper in 1985, according to Brickner (2003).

In Australia, Jenkins and Macpherson (2003) stated that hydatid disease (*Echinococcus granulosus*) was probably introduced from Europe with sheep and dogs in the 1800s and the Australian Wildlife Health Network (2009)stated that hydatids had been recorded in wombats and macropods, such as brush-tailed wallabies, eastern grey kangaroos and tammar wallabies. Typically the hydatid cysts develop in victims' lungs and are potentially fatal to smaller species, such as endangered rock wallabies and the bridled nail-tail wallaby. Dingoes, dingo-domestic dog hybrids and foxes also carry hydatids. Murray Valley Encephalitis is carried by birds, terrestrial mammals, marsupials and dogs (Chapman et al, 2005).

3.7.3 Disease transmission to estuarine and marine mammals

Faecal contamination has the potential for the transmission of a wide range of diseases to native wildlife, including those species inhabiting freshwater and marine ecosystems.

Several authorities have quantified the volume of dog faeces produced in particular areas over a given period of time (Slagle and Meiburg, 2001; The US Clean Water Campaign, n.d.). Van der Wel (1995) stated that there were 23,000,000 coliform bacteria in one gram of dog faeces. Excrement also results in algal growth, due to the excessive plant nutrients.

Recent developments in molecular biology have enabled more precise determination of the source of bacterial contamination of waterways. Dogs are by no means the only contributor of bacterial pollution of waterways, but in many cases they are a co-contributor, (Trial and Slaughterbeck, 1993; Moriarty and Gilpin, 2009; Geldreich, 1996; Rogers et al. 2007). However, Bate et al (1997) found that dog faeces were not a significant contaminant in their investigation into the origins of faecal contamination in the lower Yarra River, Melbourne, Australia. Instead they found human faecal material and that from herbivorous livestock were the major contributors. Similarly, Miller and Howell (2008) contended that dog faeces in stormwater is not as big a problem as thought and that bird droppings are a more serious contaminant.

However, of importance for Tasmanian estuarine species, Green (1997) found that stormwater entering the Derwent Estuary contributed a high level (80-90%) of faecal coliform material and stated that "*Considerable health risks to humans in estuaries receiving waters*" (Green 1997: 153). Using recently

developed sterol and bacterial composition analysis, Green was able to show that dog faeces was the major potential source of faecal pollution in Hobart's urban runoff. Interestingly, the emphasis thus far on Derwent Estuary pollution appears to have been on the ramifications for human health, rather than for native species such as the platypus (*Ornithorhynchus anatinus*), pinnipeds and cetaceans (pers. obs.).

The proportion of dog faecal contamination spatially and temporally depends upon various factors. For example it can be expected to be elevated after a period of rain has resulted in faeces being washed from surrounding areas into urban stormwater systems, whilst farmers permitting cattle access to waterways may reduce the overall percentage of dog faeces being detected. This is, of course, only because the additional bovine faecal material raises the total quantity; the total canine faecal material is not reduced.

When Kuiken et al (2006) checked Caspian seal (*Phoca caspica*) carcasses they found that that 11 out of 13 exhibited canine distemper as the primary diagnosis.

Seals and dolphins were at particular risk from xenobiotic accumulation in industrialised region coastal waters due to the presence of toxic material affecting their immune responses, due to their position at the top of the food chain, according to De Swart et al (1995). As examples they cited the 1988 infection of harbour seals (*Phoca vituline*) with phocine distemper, the 1987 US Atlantic Coast morbillivirus infection of bottlenose dolphins (*Tursiops truncates*), the mass mortalities of Mediterranean striped dolphins (*Stenella coeruleoalba*) and Siberian Baikal seals (*Phoca sibirica*).

Their study involved feeding an experimental group and a control group of harbour seals with herring from (a) a known contaminated location (Baltic Sea) and (b) a relatively uncontaminated location (The Atlantic Ocean) for a two year period. They found that the contaminated fish fed to the experimental group of seals resulted in an impaired immune function.

Given that the seals from both groups were fed on uncontaminated herring for a year prior to the start of the study, and were recruited as pups from the same area of NE Scotland, they concluded that seals born in contaminated regions may suffer increased immunotoxic chemical contamination compared with those in the study group.

A serological survey was used by Lynch et al (2011) to assess the risk of disease in Australian fur seals (*Arctocephalus pusillus doriferus*). Whilst they found no evidence for the presence of several potential pathogens which would adversely affect marine mammal health, they did find an unidentified *Brucella* sp. presence in 57% of samples. Lynch et al (2011) concluded that Australian fur seals needed to be monitored, due to the risks of introduced disease. Such monitoring would seem to be of vital importance since Green (1997) found that the level of Aliphatic hydrocarbons in Prince of Wales Bay (Derwent Estuary, Tasmania) sediments were higher than those recorded for any other Australian estuary.

Given the 1995 findings of De Swart et al regarding marine pollution, should we be concerned for the health of pinnipeds and cetaceans in the Derwent Estuary? The answer should be in the affirmative, given the possibility of the southern right whale (*Eubalaena australis*) gradually re-establishing a seasonal population (Derwent Estuary Program, 2009b; Naido, 2010) and that several

other cetacean and pinniped species are recorded for the Derwent Estuary: humpback whale (*Megaptera novaeangliae*), orca (*Orcinus orca*), bottle-nosed dolphins (*Tursiops truncatus*), common dolphins (*Delphinius delphis*), Australian fur seal (*Arctocephalus pusillus*), New Zealand fur seal (*Actocephalus fosteri*), leopard seal (*Hydrurga leptonyx*), southern elephant seal (*Mirounga leonia*) and the Australian sea lion (*Neophoca cineria*) according to Aquenal (2008) and the Derwent Estuary Program (2009b). It should also be noted that Charlton-Robb et al (2011) have described a new species of dolphin in Tasmanian waters, the Burrunan dolphin (*Tursiops australis*).

A study of southern sea otters (*Enhydra lutris nereis*) found they were susceptible to infection by *Toxoplasma gondii* via coastal freshwater run off on the Californian coast, (Miller et al 2002) whilst Kannan et al (2007) found a range of pathogens, bacteria, fungi and parasites were frequently responsible for death in Southern sea otters off the Californian coast. They concluded this possibly indicated a depressed immunological response due to '*significantly higher*' PCB concentrations in otters with infectious diseases, indicating that PCB contamination may predispose otters to increased risk from infections. This was consistent with the slower population growth of the Californian population, as compared with those in Alaska. Mustelids, such as Giant Amazon otters (*Pteronura brasliensis*) were at risk from canine distemper (Pain, 1997).

3.8 Hybridising with native dogs

Veitch (2002) recorded cross breeding with dingoes in Australia and Thailand, wolves in Italy and Norway and the Simien jackal; whilst Ebenhard (1988),

and Brickner (2003) also referred to hybridisation with native canids as an issue.

3.9 Effects upon native vegetation

The extinction of paca (*Cuniculus* sp.), brocket deer (*Mazama* spp.) and Azara's agouti (*Dasyprocta azarae*) in the Santa Genebra Reserve in Brazil could disturb seed dispersal of local plants, which would have flow on consequences for forest vegetation structure (Galetti & Sazima, 2006). Similarly, Larson and Gallie (2010) pointed out that the reduction in cassowary numbers in Queensland's Mission Beach area could result in extensive vegetation change, as the birds spread the seeds from around 100 species over their extensive home ranges.

3.10 Other disturbance effects

In the USA 52,000,000 pet dogs eat as much food as 26,000,000 people, and Coppinger and Coppinger (2011) calculated that the development of commercial dog foods had resulted in 15,000 sq. miles of agricultural land being diverted from human food production in order to satisfy the need for dog food in the USA. The use of whale meat as dog food in Japan was alleged by Lewis and Henderson (2006) and the ABC (2006). Lonsdale (2005) pointed out that commercial dog food also required packaging and transporting. This would clearly add to the quantity of steel used for tins, paper for labels and plastic for other packaging.

Chapter 4 The relative rates of death and injury to native wildlife in Tasmania: a comparison between domestic cats (*Felis catus*) and domestic dogs (*Canis familiaris*)

4.1 Introduction

This work is important because an objective ranking of the key factors responsible for wildlife decline in the suburban and peri-urban area will help to better focus remedial measures. The comparison between the predation rates of cats and dogs attempts to put dog predation into some perspective.

4.2 Methods

Three separate sets of data were accessed in order to compare the rates of death and injury on native wildlife in Australia from cats (*Felis catus*) and domestic dogs (*Canis familiaris*). These were (a) records of wildlife presenting for care through the Resource Management and Conservation section of the Tasmanian Department of Primary Industries, Parks, Water and Environment, (b) records provided by the Australian Wildlife Health Centre - Wildlife Hospital at Healesville Sanctuary in Victoria (Hammersley, pers. com.) and (c) diaries maintained by 11 Tasmanian veterinary practices over the months of March, April and May 2011.

4.3 Data from the Tasmanian Resource Management and Conservation Service: 2006-May 2011.

After rejection of incomplete and ambiguous records, the Tasmanian Resource Management and Conservation data consisted of 4,350 useable records of attacks. A significant proportion gave no known cause of injury (1,968). Of the stated causes of injury or death to native wildlife, motor vehicles were the most significant, with 1,256 cases. Dogs were responsible for 238 presentations and cats 152.

It should be noted these records related to attack episodes. In some cases several individuals were killed or injured in the one attack, such as the attack by a dog or dogs that killed 30 little penguins (*Eudyptula minor*) in a single incident. It should also be recorded that Frazer-Oakley (pers. com. 2011) suggested that dogs may be responsible for some wildlife road kill, by chasing animals onto the road.

Other possible confounding influences include where dogs or cats picked up a specimen which had been injured by some other cause, for example window strike, motor vehicle or entangled in netting.

4.4 Domestic dog attacks

Dogs targeted a wide cross section of fauna, including both diurnal and nocturnal species.

4.4.1 Mammals

As a class, mammals were far more likely to be killed or injured by dogs with 192 attacks than either birds (n=37 attacks) or reptiles (n=12 attacks). Of these, the macropods were the most likely single group to be attacked by dogs,

with pademelons (*Thylogale billadierii*) suffering 30 attacks. Bennett's wallaby (*Macropus rufogriseus*) with 17 presentations, potoroos (*Potorus tridactylus*) with 2 and a single bettong (*Bettongia gaimardi*). There were a further 14 macropods presenting, but the species identity was not noted in the records.

Possums were represented by both larger species, the brushtail (*Trichosurus vulpecula*), 34 cases, and the ringtail (*Pseudocheirus peregrinus*) with six cases. A further six possum specimens were not identified.

Bandicoots, as a group, returned 39 records. The eastern barred (*Perameles gunnii*) accounted for 29, and the smaller southern brown (*Isoodon obesulus*) six records. A further six were recorded generically as bandicoots.

Other mammals featuring in moderate numbers - as compared with wallabies, possums and bandicoots – were echidnas (*Tachyglossus aculeatus*), 17, and Tasmanian devils (*Sarcophilus harrisii*), 15. The only other mammals in the Resource Management and Conservation records were wombats (*Vombatus ursinus*) and eastern quolls (*Dasyurus viverrinus*) with two recorded attacks for each.

4.4.2 Birds

None of the bird species recorded attacks by dogs in double figures. However, one of the eight incidents of attacks on little penguins (*Eudyptula minor*) resulted in 30 deaths. There were five attacks upon unspecified species of duck and three upon masked lapwings (*Vanellus miles*). The gulls were represented by kelp gulls (*Larus dominicanus*) and Pacific gulls (*Larus pacificus*) with two attacks and one respectively. Brown falcons (*Falco berigora*) and magpies

(*Gymnorhina tibicens*) each recorded two attacks, whilst all the following bird species recorded single attacks: black swan (*Cygnus atratus*), green rosella (*Platycercus caledonicus*), kookaburra (*Dacelo novaeguineae*), Lewin's rail, (*Rallus pectoralis*), pelican (*Pelecanus conspicillatus*), sulphur crested cockatoo (*Cacatua galerita*), currawong (*Strepera* sp.), Tasmanian native hen (*Gallinula mortierii*), tawny frogmouth (*Podargus strigoides*), and a wattle bird sp.

4.4.3 Reptiles

Only two reptile species were recorded as being killed or injured by dogs in the Tasmanian Resource Management and Conservation records. These were the blue-tongue lizard (*Tiliqua nigrolutea*) with 11 recorded attacks and a single tiger snake (*Notechis scutatus*)

4.5 Domestic cat attacks

4.5.1 Mammals

As with domestic dogs, domestic cats were recorded as being responsible for more mammal deaths and injuries (93), than birds (59), or reptiles (two). Bandicoots were a major target, with the eastern-barred being the victim on 33 occasions, and the southern brown on 15. A further nine records did not mention which bandicoot species was involved. Ringtail possums (15) were much more likely to be attacked than brushtailed, three, sugar gliders (*Petaurus breviceps*) three, or the pygmy (*Cercartetus nanus*) or little pygmy (*Cercartetus lepidus*), with one attack recorded for each.

A major difference in the cat attacks to those in dogs was the very small number of wallabies being attacked; with a total of six reported. Three pademelons, two potoroos and one unidentified species recorded as being attacked once. The only other mammal species in the Resource Management and Conservation records were five bats, with only one of these (*Vespadelus vulturnus*), being identified and a single swamp antechinus (*Antechinus minimus*).

4.5.2 Birds

The rosellas appear to be the most frequently recorded bird target for cats, with eight eastern rosellas (*Platycercus eximius*), five green rosellas (*Platycercus caledonicus*) and an unstated specimen. The honeyeaters were represented by five New Holland (*Phylidonyris novaehollandiae*) and the wattlebirds, species not stated, with five.

The rest of the bird species were accounted for with four each for silvereye (*Zosterops lateralis*) and musk lorikeet (*Glossopsitta concinna*), three welcome swallows (*Hirundo neoxena*) and two each for masked lapwing, magpie, owlet night jar (*Aegotheles cristatus*) and Tasmanian native hens. The remaining species were only recorded once: eastern spinebill (*Acanthorhynchus tenuirostris*), grey fantail (*Rhipidura fuliginosa*), kookaburra (*Dacelo novaeguineae*), noisy miner (*Manorina melanocephala*), tawny frogmouth (*Podargus strigoides*), dusky wood swallow (*Artamus cyanopterus*), bronzewing pigeon sp. (*Phaps* sp.), robin (*Petroica* sp.), rosella (*Platycercus* sp.), and honeyeater sp., with five other unstated bird species.

4.5.3 Reptiles

Reptiles recorded as suffering cat attacks were a single blue-tongue lizard and a single white-lipped snake (*Drysdalia coronoides*).

Table 4-1

Species reported as attacked by cats and dogs – Resource Management and Conservation records (2006-mid 2011)

Species	Dog attacks	Cat attacks	Total
Possum, brushtail	34	3	37
Wallaby, pademelon	30	3	33
Bandicoot, eastern barred	29	33	62
Wallaby, Bennett's	17	0	17
Echidna	17	0	17
Tasmanian Devil	15	0	15
Wallaby spp. (not indicated)	14	1	15
Lizards, blue tongue	11	1	12
Possum, ringtail	9	15	24
Penguins	8	0	8
Possum spp.	6		6
Rosella, eastern	0	8	8
Bandicoot, southern brown	6	15	21
Bat species	0	5	5
Duck spp.	5	0	5
Honeyeater, New Holland	0	5	5
Lorikeet, musk	0	4	4
Bandicoot spp.	4	9	13
Silvereye	0	4	4
Lapwing, masked	3	2	5
Swallow	0	3	3
Possum, sugar glider	0	3	3
Gulls, Pacific	1		1
Gulls, kelp	2		2
Birds of Prey	3		3
Wombat	2		2
Wallaby, potoroo	2	2	4
Quoll, eastern	2		2
Magpies	2	2	4
Bird spp. (not identified)	2		2
Wattle bird	1	5	6
Owlet nightjar	0	2	2
Wallaby, bettong	1		1
Possum, pygmy		1	1
Possum, little pygmy		1	1

Table 4.1 (continued)

Antechinus		1	1
Tawny Frogmouth	1	1	2
Tasmanian Native Hen	1	2	3
Swan, black	1		1
Snake, tiger	1	0	1
Snake, whip	0	1	1
Rosella, green	1	5	6
Rail, Lewin's	1		1
Pelican	1		1
Kookaburra	1	1	2
Fantail, grey	0	1	1
Spinebill, eastern	0	1	1
Currawong	1		1
Cockatoo, sulphur crested	1		1
Wood-swallow, dusky	0	1	1
Teal	0	1	1

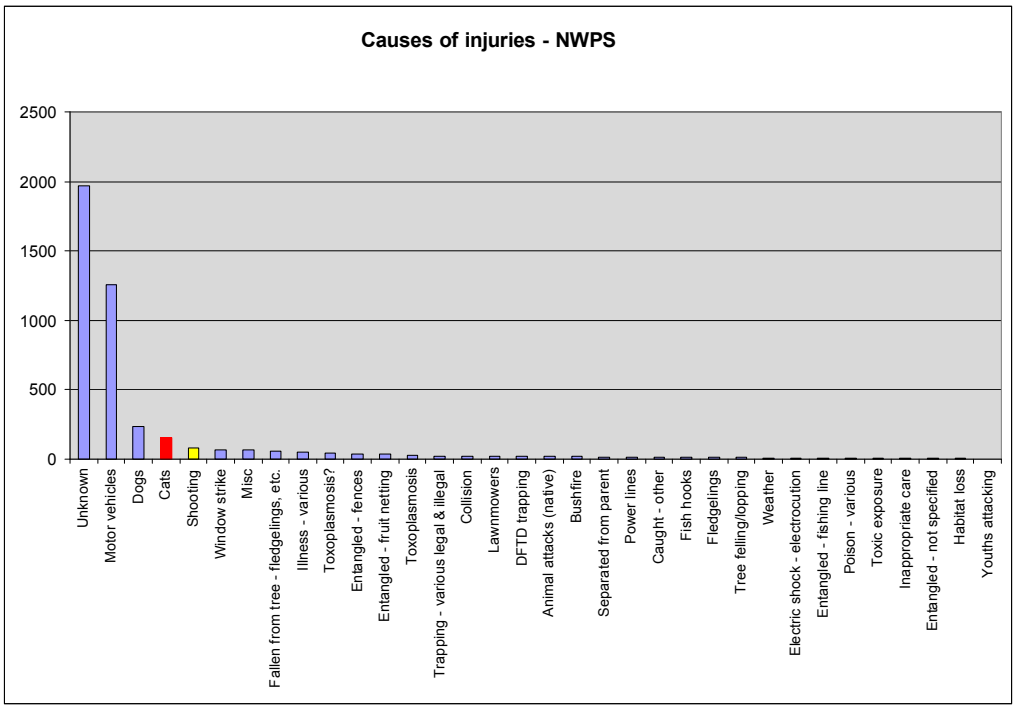

Figure 4 – 1 Causes of death and injuries to wildlife presenting through Resource Management and Conservation

4.6 Summary of results

4.6.1 Use of animal care databases

Results gleaned from records kept by other agencies for particular purposes need to be treated with some caution, as Koenig et al (2002) stated when they canvassed the use of 'unconventional' datasets such as WIRES. Although these may provide large sample sizes, they are unlikely to record specimens killed outright, and presentation of wildlife for care may increase immediately after publicity in the media. However, Koenig's comments about lack of presentation of dead specimens need some qualification as many orphaned specimens were presented, thereby indicating a level of wildlife mortality in the Resource Management and Conservation records. The records also indicated specimens that were either dead on arrival, or that died from their injuries post presentation.

Not all injured/killed specimens will be found, as injured animals tend to seek cover in vegetation or in a hole. Cats are thought to be more likely than dogs to bring specimens home: indeed, some studies of cats' prey have relied upon this assumed characteristic (Baker et al, 2005; Paton and Rogers, 2006).

However, personal observation indicates that this behaviour may vary widely between individual cats, and some cats may have more than one 'home'. Therefore, simply counting specimens brought home by a cat may under represent that cat's catch totals.

Clearly some species are at particular risk of attack by dogs, whilst others are more at risk from cats. Some species are at relatively high risk from both cats and dogs; resulting in high combined totals.

4.6.2 Dog attacks

The species at particular risk from dogs are brushtail possums, with 34 recorded attacks, compared with three cat attacks. Similarly the larger wallaby species, pademelon (30 dog, three cat attacks), Bennett's wallaby (17 dog, zero cat attacks) were more at risk from dogs. The record for unidentified wallaby species were 14 for dogs, with only one for cats. Other species identified as being dog victims, but not cat victims, were echidna, (17), Tasmanian devil (15), little penguins (8), unidentified duck species (5), birds of prey (3), wombats (2), with one each for pelican, currawong and sulphur-crested cockatoo.

4.6.3 Cat attacks

Cats were more likely to attack the bandicoot species: 33 attacks on eastern-barred, compared with 29 for dogs; 15 attacks on southern brown, compared with six dog attacks, and nine attacks upon unidentified bandicoot species, compared with four for dogs. As a total, cats attacked 57 bandicoots, with dogs responsible for 39 attacks. Cats were also more likely to be recorded as attacking ringtail possums, 15 compared with nine for dogs and the smaller possum species – sugar gliders (three) and pygmy and little pygmy possums, (one attack each).

Smaller bird species were also more at risk from cats. These included wattle bird spp. (five for cats, one for dogs), owlet nightjars (two), eastern rosellas (eight), green rosellas (five for cats, one for dogs), grey fantails (*Rhipidura fuliginosa*) (one), eastern spinebill (*Acanthorhynchus tenuirostris*) (one), dusky wood-swallow (*Artamus cyanopterus*) (one) and teal (one).

Dogs attacked 11 bluetongue lizards (cats one) and one tiger snake, whilst a cat accounted for a single white-lipped snake.

4.6.4 Species at particular risk

Several species are at particular risk of attack from either cats, dogs or both. The bandicoot species, with eastern-barred (total 62), southern brown (21), and unidentified/recorded species (13) totalled 96 attacks from cats and dogs.

Brush-tail possums (37), ringtails (24), sugar gliders (3) and pygmy and little pygmy possums (one attack each) accounted for a total of 66 attacks. The wallabies were also targeted in larger numbers; with pademelon (33), Bennett's (17), potoroo (4) and unidentified species (15) accounted for 69 attacks.

The only other species to be recorded in double figures were echidna (17), Tasmanian devil (15) and blue-tongue lizard (12).

4.7 Data from Healesville Wildlife Hospital

The Australian Wildlife Health Centre - Wildlife Hospital at Healesville Sanctuary in Victoria supplied records of native wildlife presenting as a result of animal attacks between 20 September 2008 and 31 January 2010, with a total of 229 records (Hammersley, G., personal communication, 2011). Of these, 115 attacks were attributed to dogs and 79 to cats.

These records showed that dogs were responsible for more attacks upon reptiles (45) than either mammals (37) or birds (33). Again, dogs were the main perpetrator of reptile attacks, whereas cats were only responsible for six such attacks. Contrary to the Tasmanian Resource Management and Conservation records, there was no significant difference between cat and dog

attacks upon birds or mammals; with dogs (37) and cats (38) for mammal attacks and dogs (33) and cats (35) for bird attacks.

As with the Tasmanian Resource Management and Conservation records, the several Bluetongue lizard species in Victoria were the most frequently attacked lizard species by dogs.

Whilst the Tasmanian Resource Management and Conservation records showed macropods to be the single largest group of mammals to be attacked, the only macropods recorded by Healesville were five Eastern grey kangaroos (*Macropus Giganteus*) attacked by dogs. There does not appear to be a logical explanation for such a difference in results.

The other noticeable difference in the mammal records was the complete absence of bandicoot species. However, this may be explained by the considerable decrease in numbers of both the eastern barred and the southern brown since Europeans settled Victoria and transformed the environment for agriculture and residential development. A population of *Perameles gunni* at Woodlands Park had become functionally extinct as a consequence of translocation of individuals to other locations (Todd et al, 2002); whilst Rees and Paull (2000) found that the Southern brown bandicoot population in south western Victoria had decreased considerably and was now only present in isolated populations in the region.

The possum species were again well represented, with dogs attacking nine brush-tailed possums and 10 ring-tailed possums. Again cats attacked fewer brush-tailed possums (2) but more ring-tailed possums (18). Cats were also the most likely to attack the smaller feather-tail and sugar gliders and microchiroptera species. However, as with the Tasmanian Resource

Management and Conservation records, dogs were the sole attackers of Echidnas (six) and wombats (two).

As mentioned above, the difference between gross numbers of bird attacks between dogs (33) and cats (35) was not significant. Dogs attacked more larger birds, such as the Sulphur crested cockatoo (three) and magpies (six). However, there is a seemingly difficult discrepancy where dogs attacked six rainbow lorikeets (*Trichoglossus haematodus*) (cats two), whilst cats attacked seven of the slightly larger crimson rosellas (*Platycercus elegans*) (dogs two). In both cases, the majority of specimens were mature.

Table 4 - 2

Species attacked by cats and dogs – Healesville records (20.ix.08 to 31.i.10)

Species	Dog attacks	Cat attacks	Totals
Lizard, blotched Blue-tongue	23	1	24
Lizard, eastern blue -tongue	15	3	18
Possum, common ringtail	10	18	28
Possum, common brushtail	9	2	11
Magpie	6	3	9
Lorikeet, rainbow	6	2	8
Echidna, short-beaked	6		6
Kangaroo, eastern grey	5		5
Snake, lowland copperhead	3	1	4
Parrot, King	3	1	4
Cockatoo, sulphur-crested	3	1	4
Ibis, sacred	3		3
Possum, sugar glider	2	7	9
Rosella, crimson	2	7	9
Tortoise, common long-necked	2		2
Wombat, common	2		2
Bat, chocolate wattled	1	3	4
Bat, lesser long-eared	1	1	2

Table 4.2 (continued)

Wattlebird, red	1	1	2
Bassian thrush	1	1	2
Lizard, shingleback	1		1
Lizard, Black Rock Skink	1		1
Koala	1		1
Swan, black	1		1
Rosella, eastern	1		1
Robin, eastern yellow	1		1
Raven, Australian	1		1
Kookaburra	1		1
Galah	1		1
Currawong, pied	1		1
Bronzewing, brush	1		1
Possum, feathertail glider		4	4
Bat, Gould's wattled		2	2
Spinebill, eastern		2	2
Quail, painted button		2	2
Noisy Miner		2	2
Bronzewing, common		2	2
Bird Sp		2	2
Lizard, Jacky		1	1
Phascogale, Brush-tailed		1	1
Willie Wagtail		1	1
Thornbill, brown		1	1
Tawny Frogmouth		1	1
Superb fairy Wren		1	1
Silvereye		1	1
Scrub wren White-browed		1	1
Sacred Kingfisher		1	1
Cuckoo, fan-tailed		1	1
Butcherbird, pied		1	1
Gull, Pacific			

Table 4-3, below summarises the results for the subset of broadly comparable species between Tasmania (Resource Management and Conservation) and Victoria (Healesville). The species selected were those common to both

studies, or which were regarded as occupying a closely similar ecological niche (e.g. sibling species).

Table 4-3

Comparison between recorded attacks on respective prey species by cats versus dogs from Resource Management and Conservation (Tasmanian) and Healesville (Victorian) records for cats and dogs

category	Species	Tas Dog attacks	Tas Cat attacks	Tas Total	Tas Dogs %	Tas Cats %	Species	Vic Dog attacks	Vic Cat attacks	Vic Totals	Vic Dogs %	Vic Cats %
bird	Cockatoo, sulphur crested	1		1	100.00	0.00	Cockatoo, sulphur-crested	3	1	4	75.00	25.00
bird	Currawong	1		1	100.00	0.00	Currawong, pied	1		1	100.00	0.00
bird	Kookaburra	1	1	2	50.00	50.00	Kookaburra	1		1	100.00	0.00
bird	Lorikeet, musk	0	4	4	0.00	100.00	Lorikeet, rainbow	6	2	8	75.00	25.00
bird	Magpies	2	2	4	50.00	50.00	Magpie	6	3	9	66.67	33.33
bird	Rosella, green	1	5	6	16.67	83.33	Rosella, crimson	2	7	9	22.22	77.78
bird	Rosella, eastern	0	8	8	0.00	100.00	Rosella, eastern	1		1	100.00	0.00
bird	Spinebill, eastern	0	1	1	0.00	100.00	Spinebill, eastern		2	2	0.00	100.00
bird	Swan, black	1		1	100.00	0.00	Swan, black	1		1	100.00	0.00
bird	Tawny Frogmouth	1	1	2	50.00	50.00	Tawny Frogmouth		1	1	0.00	100.00
bird	Wattle bird	1	5	6	16.67	83.33	Wattlebird, red	1	1	2	50.00	50.00
reptile	Lizards, blue tongue	11	1	12	91.67	8.33	Lizard, blotched Blue-tongue	23	1	24	95.83	4.17
reptile	Snake, tiger	1	0	1	100.00	0.00	Snake, lowland copperhead	3	1	4	75.00	25.00
mammal	Bat species	0	5	5	0.00	100.00	Bat, chocolate wattled	1	3	4	25.00	75.00
mammal	Echidna	17	0	17	100.00	0.00	Echidna, short-beaked	6		6	100.00	0.00
mammal	Possum, brushtail	34	3	37	91.89	8.11	Possum, common brushtail	9	2	11	81.82	18.18
mammal	Possum, ringtail	9	15	24	37.50	62.50	Possum, common ringtail	10	18	28	35.71	64.29
mammal	Possum, sugar glider	0	3	3	0.00	100.00	Possum, sugar glider	2	7	9	22.22	77.78
mammal	Wallaby, Bennett's	17	0	17	100.00	0.00	Kangaroo, eastern grey	5		5	100.00	0.00
mammal	Wombat	2		2	100.00	0.00	Wombat, common	2		2	100.00	0.00

4.8 Data from Tasmanian veterinary diaries

All identifiable Tasmanian veterinary practices were invited to maintain a diary of native wildlife presenting for treatment during the months of March, April and May 2011. Whilst 15 practices volunteered to keep diaries over the period, only 10 completed diaries were returned by the end of July 2011.

Practices were asked to state (a) whether the diaries were representative of expected results for a similar period, and (b) what percentage of wildlife presentations were actually recorded in the diaries. This latter question was asked in recognition that veterinary practices can be extremely busy at times, and that diary completion could be overlooked. Four practices indicated that 100% of presentations had been recorded, another practice 95% or more, two at least 80% and another 70% or more. Another two did not respond to the question. Six practices indicated their results were representative, two others stated different results would occur when there were youngwildlife around, and two failed to a respond to the question. One practice returned the completed diary sheet without any indication where it came from.

Once collated, these diaries provided 187 records. Cats and dogs were each recorded as being responsible for eight attacks on native wildlife, with another attack being designated as either a cat or a dog attack, and another a questionable cat attack.

The figures do not appear to present any conceivable pattern due to the low numbers, but as in the other cases wombats, echidnas, bluetongue lizards and larger snakes were recorded as being dog victims. One difference from the

previous figures is that dogs were responsible for the only two reported attacks on ring-tailed possums.

It is submitted that the dataset from the Tasmanian veterinarians' diary records is insufficient to provide reliable information for comparison with the other two data sources.

Table 4-4

Summary of responses from Tasmanian veterinary practices

Species	Dog attacks	Cat attacks	Totals
Possum, ringtailed	2	0	2
Wren, blue	1		1
Echidna	1		1
Wallaby spp.	1		1
Wombat	1		1
Lizard, blue-tongue	1		1
Snake, tiger	1		1
Snake, tiger or copperhead	1		1
Wattlebird sp	0	2	2
Gull sp.		1	1
Honeyeater spp.		1	1
Lorikeet, musk		1	1
Rosella, eastern		1	1
Thornbill spp.		1	1
Bandicoot sp.		1	1
Possum, little pygmy		1	1

4.9 Summary

Whilst domestic and feral cats have been demonstrated to be a significant predation risk for smaller vertebrate species, this analysis clearly indicates that domestic dogs may be an even more significant predator on some species in urban natural areas and on and near beaches, where people regularly walk their dogs, particularly if they are off leash. The combined effect of both cats and

dogs on some species, for example bandicoots, is a cause for concern in isolated, fragmented urban natural areas.

Because Tasmania is not considered to have a significant feral dog problem (Davies, pers. com., 2011) it would be unsafe to extrapolate these findings to locations away from human population, as feral cats are possibly more abundant in proportion to dogs in these locations. This could be worthy of further study.

4.10 Suggestions for future practice:

1. Vets and Resource Management and Conservation staff should be encouraged to keep more complete records of wildlife presenting as a result of encounters with vehicles and pets, particularly regarding species, location and cause of death or injuries.
2. Where possible, specimens should be photographed to confirm species or assist identification where the species is unknown.

This study was granted ethics approval by the Tasmanian Social Science Human Research Ethics Committee, project no. *H11660*.

Chapter 5 Attitudes and compliance

5.1 Introduction

The Hobart Dog Walking Association (2008) website claimed that:

> *"Dog-owners encounter pervasive claims that dogs are a threat to wildlife. While we acknowledge that this can be true where off-lead dogs are out of control and poorly-trained, this ignores more serious threats from human activity, including projects sanctioned or implemented by councils, road-kill by hooning and careless driving, and by feral animals, notably cats. The difficulties and frustrations of on-lead bushwalking to both dogs and owners are either little understood by non-dog owners, or represent an underlying agenda to de facto exclude dogs entirely. Exclusions or restrictions should be supported by evidenced-based and site-specific reasoning. Otherwise the requirements of the Dog Control Act regarding effective control, and the sanctions therein against dogs killing wildlife should suffice. Except in specially sensitive areas, we see no good reason why dogs should not be allowed off-lead in bushland areas and reserves during daylight hours. Night time access can also be allowed on-lead."*

The association correctly identified other sources of wildlife threats such as vehicles, land clearance and cats; yet it seemed unable to comprehend that these effects are cumulative with dogs and all contribute to wildlife harassment. Furthermore, the HDWA actively sought to have off-leash dog exercising permitted in an area of Poimena Reserve in Austins Ferry that it was aware had recently been revegetated to provide refugia for bandicoot spp., lizards and ground foraging birds (personal observation).

More recently Waterhouse (2011) reported that the Kingston and Hobart Dog Walking Associations had formed the Tasmanian Dog Walking Club to lobby for suitable dog walking areas and dog owner education.

5.2 Leash law compliance

Several studies and casual observation reveal that some dog owners show little responsibility towards wildlife. Key indicators of responsible dog ownership may be considered to be compliance with leash laws, and removal of faeces.

Various degrees of non compliance with dog leash law was reported by Yalden and Yalden (1990); Bekoff. and Ickes (1999); Chester (2001); Lafferty (2001); Mertz (2002); Ruhlen et al (2003); Lafferty et al (2006); Antos et al (2007); Williams et al (2009); Acevedo-Guti´errez et al (2010); Knowler (2010); Iijima (2010); Manusu (2011) and Burns (2011). This was as high as 90% in the Angeles National Forest (Chester, 2011). These findings are consistent with casual, personal observations in reserves in the Greater Hobart area, where some regular visitors always walk their dogs off leash in on leash only areas, and in areas where dogs are not permitted.

A study by Williams et al (2009) reported that 82% of 2,847 dogs on Victorian beaches were unleashed, and 88% of 693 were unleashed at Mornington Peninsula National Park. Participants were mostly aware of the regulations regarding leashing dogs on beaches, and the penalties for contravention. Dog owners' compliance with leash laws may depend upon their attitudes towards wildlife protection and dog recreation on beaches, according to Williams et al (2009). If owners thought their dog's recreation to be important, they were less likely to leash it. Some owners may also have a poor understanding of the

effects of unleashed dogs on beach wildlife, and there is an apparent belief that their particular dog would be less of a problem to wildlife than dogs in general.

The Tasmanian Dog Control Act (2000) defines effective control of off leash dogs as requiring the dog to be in close proximity and visible to the person accompanying it, and must be immediately responsive to that person's commands. However, sixty nine percent of walkers felt "close control" meant that a dog could be out of sight, but would return when called according to Liley et al (2006:38), and fifty-seven percent thought "*only a few owners would keep their dog on a short lead during the bird breeding season if asked*".

5.3 Faecal collection

Liley et al. (2006) found only 53% of dog-walkers on Dorset Heaths in the UK always cleared up after their dog, but 33% said they would only do so if the dog fouled the main footpath, whilst Mertz (2002) noted only 59% picked up their dog's droppings in reserves in Boulder, Colorado, USA. Of course, if a dog is straying without its owner, these faeces will not be collected either.

5.4 Attitude surveys

In a survey of recreationists, 50% of respondents felt their recreation was not affecting wildlife and they considered it was acceptable to approach wildlife more closely than the minimum distance for a species to avoid disturbance (Taylor and Knight, 2003).

A survey of dog owners and non dog owners in Boulder, Colorado by Bekoff and Meaney (1997) regarding their attitudes towards dog control found there was general agreement between the two groups for stricter enforcement of voice and sight control (66% for dog owners and 76.6% for non dog owners)

and both groups wanted additional areas for off-leash dog exercise (64.3% for dog owners and 72.3% for non dog owners). There was also strong minority support for standardised dog obedience tests (42.7% for dog owners, compared with 48.2% for non dog owners) and an annual fee for dogs using open space (37.3% for dog owners and 55% for non dog owners). Interestingly, respondents from both groups thought that unruly people were a bigger problem than dogs.

In the UK, Johnson and Whyte (2008) surveyed dog walkers using the trail alongside the Itchen Navigation River between Winchester and Southampton. Fourteen dog walkers out of a total of 92 (15%) said they would never use specially provided 'dog dips' to help reduce damage to river banks by dogs scrambling up them. This may be a small number, but indicates that some dog owners will not co-operate with authorities in order to safeguard the environment.

5.5 Aggression and vandalism

Fortunately, overt aggression towards volunteer wildlife carers does not appear to be common, but Jacobsen (2011) reported a 72 year old volunteer penguin guard at Manley Cove, NSW was assaulted by a youth when she tried to prevent a dog from chasing a penguin. Only five penguin pairs were left in the colony, as seven had been killed in a dog attack the previous month.

Vandalism of signs and fencing is a more common practice (pers. obs.) and Donefer (2003) related that vandals tore down a protective fence surrounding a western snowy plover nesting site and someone stepped on a nest.

5.6 Local government responses

The Australian Veterinary Association (2008) statement on socially responsible companion animal ownership stated that all levels of government were responsible for legislating for the welfare of the animal and protecting the environment. Local government has the major responsibility for monitoring compliance and enforcing the *Dog Control Act 2000* in Tasmania.

Dog owners in Berkeley, California would let their dogs out early, before the Animal Control officers were on duty, whereas more responsible owners took their charges for walks later (Berman and Dunbar, 1983). Personal observation over many years indicates that some dog owners employ similar tactics to avoid council scrutiny in Tasmania.

The attitudes and actions regarding compliance in Tasmania by local councils varies. For example, Glenorchy City Council only has animal management staff available outside normal work hours for emergency situations, as outlined by Taylor (pers. com., 2010): "*The policy is strongly focussed on emergency situations, such as dog attacks or other such incidents where a person or person's safety may be at risk, and is not intended for routine or minor infringements of the regulations.*" Reasons given for this policy included a lack of evidence for a need for patrol or enforcement outside normal working hours, exposure of staff to conflict and stress.

In contrast, the Glamorgan Spring Bay Council on Tasmania's east coast, who advertised in the press that their officers would be patrolling beaches, reserves and streets over the forthcoming Christmas – New Year holidays in December 2010 (Smith, 2010) is clearly more proactive regarding the implementation of

dog legislation. Similarly, Clarence City Council had staff patrolling their beaches for dogs on the Australia Day 2011 public holiday (pers. obs.) and both Sorell and Tasman Councils indicated they paid particular attention to dogs on beaches over holiday periods (Smith, 2010). However, the motivation for beach controls seemed to come more from consideration for other human visitors, rather than for the environment. Baker's (2011) survey of three dog walking beaches in southern Tasmania indicated that Bellerive beach was regularly visited by Clarence CC staff to monitor dog walking and enforce regulations, however council inspectors seldom visited the Kingston and Sandy Bay beaches, although people seemed to conform to signed regulations.

In summary, it can be stated that many owners fail the test of responsible dog ownership, by failing to keep dogs on leash where required, and by not picking up faeces. There is also some difference between councils' response to dog issues, which may justify further investigation.

Chapter 6 Remediation and mitigation

6.1 Introduction

Jackson (1995) stated that increased demand for smaller homes and gardens will lead to an increased demand for access to public open space for dog exercising. For this reason, it is important to consider options to mitigate any conflict between dogs and the environment. A strong case for invoking the precautionary principle, when considering responses to the effects of stray cats on the environment, was made by Calver et al (2011). They promoted a suite of responses including sterilisation, registration, confinement to owners' premises and 'collar-mounted predation deterrents'; and suggested these proposals should be implemented until further research clarified the effects of cats on the decline of wildlife populations. Given that dogs have been shown to kill or injure more wildlife than cats, at least in some circumstances, similar precautionary principals should be applied to dogs in sensitive wildlife areas such as beaches and in suburban and peri-urban reserves with remnant vegetation.

A range of mitigation options has been proposed to reduce the effects of dogs on native wildlife. These include education, visitor supervision, better planning of natural areas reserves, fencing off areas, signs and monitoring dog activities and enforcing the legislation where appropriate.

6.2 Education and Supervision

Education is possibly the most frequently proposed remediation method for use when there is a human versus wildlife conflict, and was proposed by Klein, (1993); Klein et al, (1995); Bekoff and Meaney, (1997); Rogers et al., (2006);

Miller and Howell, (2008); Srbek-Araujo and Chiarello, (2008); the Derwent Estuary Program, (2009); and Page and Thorp, (2010), amongst others.

The term 'education' is an umbrella term used by many people to cover a range of strategies for providing information in the hope of changing attitudes and behaviour towards wildlife. These strategies include dissemination of printed materials (the Atlanta, USA *Clean Water Campaign*, n.d) and The Northumberland Coast Area of Outstanding Natural Beauty (AONB) Partnership (2011). However, Heimlich and Ardoin (2008) looked at education for behavioural change and concluded that simply giving people information and telling them to change their behaviour was ineffective; similarly McKenzie-Mohr (1999) pointed out that behaviour change seldom results from simply providing education. This concurs withthis author's personal observations during a career of more than thirty years as an adult educator.

In order for education to be effective in attitude and behaviour change, engaging with dog owners and others has been recognised as the most effective form of education by Parkin and Parkin (2001), Woolnough (2011), Burns (2011) and Birds Tasmania, (2011).

The presence of an official looking volunteer observer dressed with a neon vest at a juvenile New Zealand fur seal colony was enough to reduce the number of times that tourists harassed young seals by two thirds (Acevedo-Guti´errez et al, 2010). The volunteer did not approach visitors, and this seems to indicate that people will harass wildlife, or permit their dogs to do so, unless there is some form of monitoring of their behaviour. Personal observation indicates that many people walking dogs off leash in leash only areas will hurriedly put

them on leash if someone approaches – and then let them off leash once they have passed.

McKenzie-Mohr (1999) promoted the concept of community-based social marketing as a means to bring about behavioural change in environmental issues. Key parts of the strategy promoted by McKenzie-Mohr (1999) included identifying barriers to change, gaining commitment from individuals, developing community norms and personal contact.

A good example of an educational project from Tasmania is that of the Fishcare volunteers program conducted by the Department of Primary Industries, Water and Environment (2003). Volunteers perform two major functions, either visiting schools to engage with students, or visit inland and coastal fishing spots to engage with the recreational fishing community. Their role is to monitor breaches of fisheries regulations and help people to understand the fisheries regulations. They do not act as police, but report back to authorities when breaches appear to be occurring (Department of Primary Industries, Water and Environment, 2003). This project could serve as a useful model for dealing with illegal dog exercising and other issues in Council managed urban natural areas, possibly under the umbrella of the National Resource Management and Conservation section of DPIPWE. Indeed, Woolnough (2011) described a particularly proactive range of engaging educational activities to encourage beach users to help with hooded plover protection in the Glamorgan-Spring Bay municipal area on Tasmania's east coast. The project relied upon using local people to make personal contact, small group meetings, one-to-one conversations at street stalls, dogs' breakfasts and walking and talking with small groups of local school children.

She emphasised the importance of keeping the message simple; for example photos of birds and feet near nests. Birds Tasmania (2011) regularly conducts '*dogs breakfasts*', such as that described on Flinders Island.

A similar model is operated by the Ipswich City Council in Queensland, as described by Court (2006). The Honorary Park Rangers program is conducted by volunteers, who report back to council staff regarding illegal conduct. Rangers also assist with park interpretation.

A study of the intention to obey rules in outdoor recreation areas, depending upon the personality of subjects and their situational factors, was made by Gramman et al (1995). Awareness of the consequences of rule breaking were considered, together with the likelihood of fear of sanctions. Awareness of consequences does not refer to consequences flowing to the perpetrator, but the consequences for the environment. [For example, a dog walker may decide to keep their dog on a leash so that it does not disturb wildlife, but one acting out of a fear of sanctions would keep their dog on leash in order to avoid a fine.] They stated that "*Socially responsible persons have an enhanced sense of commitment to the collective good, a strong tendency to delay personal gratification, and a proclivity to help others ...*" Gramman et al (1995: 329). People with a strong social responsibility trait will respond more favourably to educational messages which state the environmental consequences of rule violation. They postulated that park visitors tended to be highly educated and this should make them more receptive to education to increase their awareness of consequences. Conversely, visitors with a lower level of social responsibility are more likely to respond to fear of sanctions. Overall, the fear of sanctions was more effective with those with both high and lower social

responsibility. The authors concluded that fear of sanctions required enforcement, with the resources needed for that; so the awareness of consequences which was less effective overall was still a worthwhile strategy. Personal observation indicates the idea that better educated visitors may be more likely to accept the 'awareness of consequences' paradigm is not necessarily true. This is supported by personal observation of the Secretary of the Hobart Dog Walking Association, who is a former University lecturer; yet he regularly lobbies for dogs to be allowed of leash in natural area reserves, in spite of being told on several occasions that off leash dogs kill bandicoots.

It is possible that educational messages could be more effective if delivered through credible channels; for example Garfield and Walker (2008) proposed that veterinarians could be recruited as partners in educating dog-owners to pick up and dispose of their animal's faeces. It is likely that the credibility of those presenting messages regarding cats and dogs in the environment is crucial to such messages being accepted and thereby influencing attitude and behaviour of pet owners. For this reason, high profile presenters of animal related shows, such as Dr Harry Cooper and Rolf Harris, would be suitable presenters for radio and television community service spots and social media, such as YouTube.

6.3 Enforcement

Whilst some writers suggested there should be less reliance on enforcement, in favour of education, (Bekoff and Meaney, 1997; Miller and Howell 2008); others suggested a need for improved enforcement, (Thomas et al, 2003; Forrest and St. Clair, 2006; Williams et al, 2009). This option needs to be

available for dealing with those who deliberately disregard the regulations concerning dogs and wildlife.

As an example, the Barrie Examiner (2011) reported that a man was fined $1,000 Canadian for allowing an unleashed dog to chase a pair of endangered, nesting piping plovers (*Charadrius melodus*) in a fenced off area of Wasaga Beach on Lake Huron; and the US State of Colorado (1984) legislation permits authorised officers to euthanase any unattended dog found harassing wildlife.

6.4 Planning and related measures

Unfortunately many of the locations used by wildlife for breeding and feeding, such as beaches and urban natural areas, are precisely those that attract dogs and their carers. It is difficult to retro-plan for wildlife due to existing development, and is expressed by Bolger et al (1997: 420) "*The species in the edge/fragmentation reduced category may be at a significantly higher risk than a simple assessment of the potential habitat in the landscape might suggest. And, their conservation in this landscape may require management measures beyond the preservation of the appropriate vegetative habitat.*"

Several authors have suggested actions that may be considered under the broad umbrella of planning. These included:

- covenants to preclude pet ownership in wildlife sensitive areas, particularly new developments near little penguin rookeries (the Derwent Estuary Program, 2009)
- limiting development in sensitive wildlife areas (Rogers et al., 2006)
- clustering of houses to permit more open space between them (Odell and Knight, 2001; Daniels, 2011).

- fencing off areas and temporary closure, particularly on beaches during the breeding season, is promoted by several authorities such as Smith and Quin (1996), Lord et al (1997), Bekoff and Ickes (1999), Donefer (2003), Ikuta and Blumstein (2003), Antos et al (2007), the Derwent Estuary Program (2009), Birds Australia (2010), Deans (2011), Natural Resource Management (NRM) South (2011), Palmer (2011) and Kennerley (2010).
- development of private land reserves (Reed and Merenlender, 2008)
- effective signage (Blackshaw and Marriot,1995; Mitchell, 2010; Woolnough, 2011)
- provision of buffer zones between wildlife and recreation areas (Stalmaster and Newman, 1978; Rodgers and Smith, 1997; Lafferty, 2001; Thomas et al, 2003; Fernández-Juricic et al, 2005)
- control of access points and location of paths, tracks and trails (Andrews, 1991; Klein et al, 1995; Lenth et al, 2006; Johnson and Whyte, 2008; Mitchell, 2010)
- limiting vehicle access (Rogers et al., 2006)
- closure of areas either to dog walking, or to all recreational activity (Taborsky, 1988; Pomerantz et al., 1988; Klein et al, 1995; Banks and Bryant, 2007; Reed and Merenlender, 2008)
- limiting the number of dog licences in order to reduce the faecal loading from dogs (Garfield and Walker, 2008)

- dealing with dog faeces, to reduce damage to waterways (Garfield and Walker, 2008)
- control of dogs' reproduction (Silva-Rodríguez and Sieving, 2011)
- provision of fenced off dog parks (Blackshaw and Marriot, 1995; The ACT Department of Parks Conservation and Lands, 2010; The City of Onkaparinga, 2010; Onondaga County Parks, 2011).
- vaccination against diseases which would adversely affect native wildlife (Pain, 1997).
- Euthanising predatory dogs (State of Colorado, 1984).

Some of these proposals are worthy of further discussion as a part of this thesis.

6.4.1 Closure and fencing off areas

There are several examples where fencing has helped to protect wildlife on beaches. Deans (2011) reported that little terns' breeding success at Hearnes Lake had increased from 16 in 2010 to 30 in 2011 due to fencing and other initiatives, and Natural Resource Management (NRM) South (2011) reported on the successful raising of a Hooded plover family at Spring Beach in Tasmania, due to the erection of a fence, information signs and regular monitoring. Electric fencing increased hatching success significantly, from 18% to 78%, for lapwings (*Vanellus vanellus*) in wet grassland areas on reserves run by the UK Royal Society for the Protection of Birds, according to Kennerley (2010).

However, fencing needs to be carefully constructed, as it can impede birds' access to areas, and render them easier to catch by predators (the Derwent Estuary Program 2009) and Smith and Quin (1996), who emphasised the need for fencing design to keep out predators, but permit passage of the smaller mammals. Safina and Burger (1983) noted that black skimmer chicks suffered minor injuries to the base of the beak when passing through fences. Rodgers and Smith (1995) suggested a set-back distance for fencing of 100 metres for wading bird colonies, and 180 metres for mixed tern/skimmer colonies as buffer zones from disturbance by pedestrians. Fernández-Juricic et al (2005) found that some birds took flight earlier if they were approached tangentially, rather than directly; concluding that buffer distances determined by direct approach flight distances may be insufficient. On another note, Lafferty (2001) cautioned for the need to anticipate the edge effect and prepare for the displacement of dogs to other vulnerable areas. For example requiring wet sand walking could concentrate people and their (on leash) dogs into areas used by other bird species.

Fencing alone may not be sufficient, and several proponents suggested that there needs to be some form of volunteer monitoring present too: (Lafferty et al, 2006; Burns, 2011 and Palmer, 2011).

Taborsky (1988) proposed that forest areas in New Zealand where kiwis were present should be closed to dogs, that areas should be searched regularly for feral dog signs and that people's activities in forests needed rigorous supervision.

Fencing in suburban areas should be designed to assist the passage of koalas and other arboreal species through an area to access trees, without having to

descend to ground level (Australian Koala Foundation, 2011). Timber post and rail or lattice fences are appropriate, but metal sheeting is unsuitable for koalas. This can be capped, and posts against the fence can provide an escape route from dogs (Australian Koala Foundation, 2011).

6.4.2 Signage

Blackshaw and Marriot (1995) suggested that signs should be less dictatorial, and should provide more positive messages to encourage compliance, and Woolnough (2011) emphasised the need to keep the message simple. Personal observation indicates that signs with too much detail will simply be ignored. It may be necessary to be discreet about the locations of some at risk species, as pointed out by Mitchell (2010) when referring to signs near penguin rookeries close to Hobart, Tasmania. These made no mention of penguins, only shorebirds, as it was felt that the site of penguins should not be made too obvious.

6.4.3 Dealing with faecal matter entering waterways

As discussed above, faecal contamination of waterways has the potential to infect estuarine and marine mammals with canid diseases, such as canine distemper. For this reason, it is important to reduce the quantity of canid faeces entering waterways, and to expedite its breaking down in the event that it does enter waterways. Garfield and Walker (2008) stated that faecal bacterial survival can be reduced by exposure to sunlight, higher temperatures and reduced moisture levels; and found that bacterial counts unexpectedly decreased from the upstream collection point to a downstream collection point.

They concluded this was because the water flowed through a sedimentation pond and riparian wetlands.

As a result of their findings, Garfield and Walker (2008) suggested that dog faecal materials should be collected away from creeks and streams, or upstream of sedimentation ponds and other treatment areas. Access points and trails should be moved away from watercourses.

Given that faecal contamination of waterways has been tagged as a potential transmission channel for diseases from dogs to estuarine and marine mammals, vaccination of domestic dogs (and cats) against disease that could adversely affect pinnipeds and cetaceans could be considered. Pain (1997) discussed vaccinations for wildlife and found some species reacted negatively to vaccinations. As a result, she proposed that the domestic species be vaccinated, in order to minimise the disease pool within the domestic population, in order to mitigate the risk of transmission to native wildlife.

6.4.4 Dog exercise parks

The idea of dog exercise parks is relatively recent in Australia, and seems to be being driven by the perceived need to keep dogs away from other human recreation activities. It does not appear to have been considered as a valid response to prevent dogs disturbing wildlife in sensitive wildlife areas. Blackshaw and Marriot (1995) proposed several design features in parks for the benefits of dogs and their owners. These include long grass for defecation areas, planting trees, hurdles, logs, tyres.

The ACT Department of Parks Conservation and Lands (2010) has provided two dog parks, one at Lake Ginninderra and one at Lake Tuggeranong.

Development was overseen by a reference group from government and dog related groups.

The Onondaga County in central New York State, USA, has developed Wegmans Good Dog Park. This is fenced off with 'tunnels, jumps, bridges and … red fire hydrants!' As well as water and waste disposal areas, the park has double gates to prevent dogs leaving unsupervised. Dogs are required to have been vaccinated, and must be under control at all times (Onondaga County Parks website, 2011).

The City of Onkaparinga in South Australia (2010) investigated the provision of fenced dog exercise areas, as a response to several petitions requesting provision of a fenced dog park. The reasons for requests included safety for dogs, separation from children, dogs need to be able to run, and owner socialisation. Key features of a dog park include fenced around 1.5 metres high, child-proof double gates, provision of water, seating, shelter/shade, room to throw balls, etc., able to view dogs at all times, provision of agility equipment, mown to reduce danger of snakes, signs with rules for users. Supporters included the RSPCA, local vet and the animal welfare community.

6.4.5 Predator control

On-going control of dogs and foxes as predators was considered to be the most effective way to preserve the swamp wallaby population of Muogamarra Nature Reserve north of Sydney, N.S.W. by Ben-Ami et al (2006).

Kruuk and Snell, (1981) concluded that the only way to guarantee the continued existence of marine iguanas on the islands of Santa Cruz and Isabela

in the Galápagos was to exterminate the feral dogs that were predating on them at an unsustainable level.

The options are limited for the control of domestic dogs that have simply strayed from their homes in Australia, although trapping, shooting and poisoning is used against feral dogs in Queensland (State of Queensland, 2010), and Buck (pers. com., 2011) described how a small population of feral dogs in the Western Tiers of Tasmania was broken up by shooting the alpha male and female.

Chapter 7 Conclusions and recommendations

7.1 Conclusions

7.1.1 Introduction

The question posed at the start of this thesis was, "*What are the effects of domestic dogs* (Canis familiaris) *as a disturbance agent on the natural environment?"* Whilst there are many natural extraterrestrial and terrestrial causes of ecological disturbance, anthropogenic induced change has become significant, particularly since the advent of the industrial revolution. Both the literature and analysis of data from the Tasmanian Resource Management and Conservation section of DPIPWE and the Healesville Wildlife Hospital strongly indicate that dogs are a major disturbance to native wildlife through predation, feeding and breeding disturbance in certain situations; and as disease vectors. They may also influence vegetation through predation upon animals that browse certain species or spread seeds via faeces or carrying on their fur.

The most likely locations where disturbance will have the greatest effect upon wildlife is where wildlife forages, rests or breeds where people exercise their dogs off leash, or permit them to roam at large. Such areas include beaches, urban and peri-urban natural area reserves. The combination of land clearance and feral or stray dogs may have significant ramifications for urban and suburban natural areas reserves, where encroaching domestic residential development has isolated populations of mammals, reptiles and flightless birds. Such areas tend to be relatively small, have fire breaks around the perimeter and tracks and trails penetrating into the vegetation, leading to an enhanced edge effect.

The use of agricultural land for pet food production, packaging and transport to markets are also effects upon the environment.

7.1.2 Consequences of disturbance

Whilst immediate mortality or severe injury of wildlife, such as flightless birds, small mammals and lizards, is a serious situation; this is only the tip of the disturbance iceberg. The mere presence of a dog off leash or unaccompanied is sufficient to disrupt foraging, resting and/or reproduction. This effect is compounded when a series of people walk their dogs in a location over the course of a day. It has been shown that several species of wildlife have declined in numbers near trails where dog walking occurs – permitted or not.

Wildlife disturbed whilst foraging faces the double jeopardy of not only having a reduced energy intake, but increased energy expenditure when forced to move elsewhere. Furthermore, such replacement areas may be less suited for foraging, due to less suitable food and/or increased risk from predation. This has the potential to reduce reproductive success and jeopardise migration. Animals forced to move into another area are going to increase competition with existing species for scarce resources, such as food, roosts or refugia.

Another key issue is that of disturbance to breeding birds, resulting in their leaving the nest. A hurried departure from a nest means that the eggs are less likely to have been covered by the parent, resulting in eggs possibly overheating or becoming chilled. Whist overheating is more likely to kill the developing embryo, chilling can affect development and result in smaller hatchlings; which in turn are less likely to reproduce satisfactorily. The other risk attached to leaving an empty nest is the possibility of egg predation.

Dogs have also been implicated in the transmission of diseases to native wildlife, either through direct contact, aerosol transmission or faecal deposits. Examples include the 1994 canine distemper outbreak which killed an estimated one third of lions in the Serengeti National Park and hydatid disease transmission to Australian marsupials. Marine mammals are also at risk from diseases transmitted by or from dogs in faeces, particularly where chemical pollution may have reduced their immune response. Examples include canine distemper in Caspian seals and *morbillivirus* infection of bottlenose dolphins. Whilst Australian marine mammals have shown little infection apart from *Brucella spp*., the serious level of pollution in The Derwent River indicates that the possibly reinvigorating whale population, platypus, dolphins and seals may be at risk from stormwater contaminated by canine faeces entering the Derwent after heavy rain.

Some authorities have suggested that predation upon keystone species may result in significant vegetative change over a large area, as such species may either control some plant species, or alternatively be the principal seed dispersal mechanism through faeces or carriage on their fur.

The pet food supply industry is a significant contributor to the economy of those countries where domestic dogs are regarded as being essential to many households. This has resulted in agricultural land being used for grain and meat production for dogs, steel and plastics being used for containing pet food and fuel for transport to the marketplace.

7.2 Recommendations

7.2.1 Local government

Local councils must accept that they have the principal role for preventing disturbance to native wildlife by domestic dogs within urban natural areas reserves and on beaches. In particular, they need to:

1. Consider the location of recreational facilities such as BBQs, tracks and trails when establishing new natural areas reserves, as a response to suburban encroachment upon former bushland areas. These facilities should possibly be located in a buffer zone, outside the reserve proper.
2. Recognise that some areas in their jurisdictions may not be appropriate for dog walking, either on or off leash; including some beaches and urban natural areas in council reserves. If these have been set aside for wildlife habitat, is it appropriate to develop trails through them which will attract dog walkers, mountain bikers and trail bikes? It may be politically difficult at the local level, but councils should review all such areas from the perspective of environmental management and biodiversity maintenance, rather than for recreational use.
3. In particularly sensitive areas, such as near little penguin rookeries, there should be a buffer zone between new residential developments, with appropriate anti-predator fencing.
4. Covenants to prevent keeping of cats, dogs and ferrets should be imposed upon new residential areas within specified distances of sensitive wildlife areas.

5. Adequately monitor dog exercising in areas where this is not permitted, including outside normal council office hours, and be prepared to issue infringement notices to non compliant dog guardians. Monitoring could be achieved through a volunteer project, similar to the honorary park rangers program established by the Ipswich City Council in Queensland. However, volunteers should not undertake enforcement roles, but advise Council officers of breaches of regulations.

6. Provide alternative dog exercise areas, with dog gym equipment such as pipes, and jumps, fresh water and bags for collecting faeces. Such areas should be away from stormwater channels and waterways, in order to reduce faecal contamination of estuarine and marine environments.

7. Provide adequate interpretive signs to explain what dog exercise regimes, on leash or off leash, are permitted and why. For example, instead of simply saying '*No dogs*' or '*Dogs must be on leash*', there also needs to be a statement that it is a sensitive wildlife area and there needs to be a good illustration of a relevant species. Signage also needs to indicate the location of appropriate on leash and off leash dog exercise areas, possibly with a map and indicating distance from the current location.

8. Recognise that much of so-called *education* is ineffective. Simply providing information will not produce the required attitudinal and behavioural change in those dog guardians who flout the dog regulations.

7.2.2 State government

The State Government is responsible for the legislation which controls dogs, through the *Dog Control Act 2000.* This Act is subject to regular review. Considerations during such reviews should include the following requirements:

1. Develop a specific definition for *sensitive wildlife areas* in urban and suburban areas that recognise their crucial role in maintaining biodiversity, requiring councils to prevent dog walking within these areas.
2. That councils develop an adequate strategy to monitor and enforce the legislation and relevant council bylaws outside normal council operating hours, when many people exercise their dogs.
3. That councils assess all urban natural areas and assess their suitability for dog exercising from the environmental perspective.
4. That councils develop suitable alternative dog exercise areas with dog gym equipment, fresh water and faeces collection and disposal facilities.
5. That councils covenant areas within a specified distance of particularly sensitive wildlife areas against cat, dog and ferret ownership, such as penguin rookeries, when new residential developments are being assessed and that such areas also be separated from sensitive wildlife areas by buffer zones and fencing.

7.2.3 Dog guardians

Dog guardians are primarily responsible for the behaviour of their dogs. At the end of the day they should observe the regulations, regardless of whether the local council officers are present. Specifically, dog guardians should:

1. Recognise that being a dog guardian has responsibilities for the safety of native wildlife and that the regulations must be observed.
2. Fences and signs regarding nesting birds on beaches are there for a reason, and should be observed implicitly.
3. That an off leash dog is only under effective control if it is in close proximity and visible to the person accompanying it, and must be immediately responsive to that person's commands.

7.2.4 Householders

Householders should be encouraged to modify fences in order to permit arboreal mammals to safely negotiate around their properties at a height that dogs are unable to reach.

7.2.5 Resource Management and Conservation records

1. Vets and Resource Management and Conservation staff should be encouraged to keep more complete records of wildlife presenting as a result of encounters with vehicles and pets, particularly regarding species, location and cause of death or injuries.
2. Where possible, specimens should be photographed to confirm species or assist identification where the species is unknown.

7.2.6 Further studies

Because the findings of this study regarding the relative damage of cats and domestic dogs to native wildlife in Australia should be regarded as being indicative, rather than definitive, the situation needs further study. It is suggested that the following investigations may be worthy of consideration:

1. Methods to further improve the differentiation between cat and dog attacks upon native wildlife, such as through injury characteristics.
2. Dog walking patterns in urban natural areas reserves: particularly time of day, compliance with leash laws and faecal collection, dogs under effective control and wildlife harassment by dogs and/or guardians.
3. Comparison of cat versus dog attacks upon native wildlife in locations isolated from human habitation.
4. Responses by Tasmanian councils to domestic dogs in their natural areas. For example, do they monitor these areas outside normal operating hours, and what action do they take against offenders?
5. Comparison of dog management policies of Tasmanian councils.
6. Vulnerability of southern right whales (*Eubalaena australis*) and other estuarine and marine mammals to infection by canid diseases transmitted by dog faeces contaminating waterways.
7. Prevalence of canid diseases within the Tasmanian domestic dog population, particularly those which may be transmitted to native wildlife, including estuarine and marine species.
8. Design and management of dog exercise parks.

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