

Dogs as agents of disturbance

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4.1 Introduction

The mere presence of a predator in an environment can affect prey in subtle, sublethal, indirect, yet apparently deleterious ways (Preisser et al., 2005; Zanette et al., 2011). The response of wildlife to the presence of a threatening stimulus, such as a dog, is referred to as ‘disturbance,’ and these responses involve the disruption of normal activities or states, and often evoke antipredator behaviors, commonly vigilance, flight, retreat to refuge, freezing behavior, or hiding (Hockin et al., 1992). Behavioral changes in the presence of a threatening stimulus have been widely documented and often involve ceasing normal activities (e.g., foraging, parental care, resting, display). A growing body of literature also points to physiological changes, such as hormone release or altered heart rates (e.g., MacArthur et al., 1982). Studies (e.g., Gill et al., 1996) demonstrate population-level effects of disturbance, essentially because disturbance effectively lowers habitat quality and thus reduces carrying capacities. A diverse range of stimuli can disturb wildlife. Dogs, often as companions to humans, are increasingly recognized as prevalent, wide-ranging stimuli that often evoke particularly strong and typically deleterious responses among wildlife (Williams et al., 2009). This may be especially true where wildlife and dogs co-occur at high densities in constrained areas, such as coasts and recreational parks. Increasingly, management solutions are being sought to mitigate the problem of dog disturbance to wildlife (Williams et al., 2009). One key information gap in relation to disturbance of wildlife, however, is differentiating the extent to which disturbance is a welfare issue, primarily impacting individual animals,

and the extent to which it is a conservation issue, reducing viability of wildlife populations (Hockin et al., 1992). This, and the way humans value and protect wildlife and their dogs, means managing dog disturbance to wildlife is a controversial topic (Williams et al., 2009).

While most studies focus on ‘pet’ dogs accompanying their owners, a few have described wildlife being disturbed by herding or hunting dogs (e.g., Sastre et al., 2009), and only a handful have considered free-ranging (a.k.a., ‘free-running’ or ‘free-roaming’), mostly unaccompanied dogs (Berger et al., 2007). Very little is known about the disturbance caused by dogs not accompanied by humans (but see Miller et al., 2001; Sastre et al., 2009), though an expanding literature examines the interaction between wildlife and dogs accompanied by people (Box 4.1). Thus, this chapter necessarily emphasizes the latter, and we acknowledge that more information is needed on disturbance caused by unaccompanied dogs. We also acknowledge a bias in available literature, which tends to focus on dog–wildlife conflicts in urban, coastal, forest, and heathland recreational areas (i.e., those areas where humans engage in leisure time activities; Box 4.1). Additionally, while there are many critical information gaps in relation to disturbance to wildlife caused specifically by dogs, some general principles of wildlife responses to threats are used here to discuss likely factors influencing disturbance to wildlife by dogs. This chapter emphasizes wild birds and mammals; while dog disturbance is also likely to occur to many reptilian and amphibian species (see Holderness-Roddam, 2011), publications are limited, and less text is devoted to these groups.

Box 4.1 The limited information base for dog disturbance of wildlife

Not only is little information evident, but clear biases exist in the available information pertaining to dog disturbance of wildlife, and we acknowledge these biases will necessarily be reflected in the emphases of this chapter. Of those biases evident, we note that most available studies are from the developed world, mostly from temperate regions, and most deal with accompanied dogs (thus not representative of most of the world's dogs). Table 4.1 presents and characterizes selected studies which deal with the issue of dog disturbance in some substantive way ($n = 35$). These studies have increased exponentially over time (Figure 4.1); 40 and 34% originate from North America and Europe respectively, the remainder from Australasia and the Middle East. Most studies (60%) deal with a single species of wildlife. Most focus on open habitats, notably coasts (49%), and 40% involved some form of experimental delivery of stimuli to wildlife, the remainder used observational techniques.

Although literature specific to dog disturbance of wildlife is limited, there has been a growing body of literature concerning the broader topic of anthropogenic disturbance of wildlife over the past 40 years, and this has been frequently and adequately reviewed (e.g., Hockin et al., 1992; Weston et al., 2012). The vast majority of this literature involves

wildlife responses to humans on foot, with less attention paid to motorized transport (vehicles, boats, aircraft, etc.) or dogs (see Weston et al., 2012). This literature describes great variation in response (extent, type, etc.) and consequences of disturbance to wildlife, and documents disturbance regimes (type, extent, and frequency of occurrence of stimuli, and the rate at which they evoke responses). The literature also elucidates some general principles that undoubtedly apply to the response of wildlife to dogs. These include: an inverse relationship between distance of a stimulus and probability and extent of the response to it, that unpredictable and 'non-benign' stimuli are associated with enhanced response, and that several attributes of wildlife (most notably increasing body mass) are associated with increased response distances (Hockin et al., 1992; Weston et al., 2012).

Despite this substantial body of work, key information gaps remain. These center around the need to explore the higher-order consequences of individual responses to disturbance (Weston et al., 2012). In particular, to date only a few studies document the population-level impacts of disturbance (Mallord et al., 2007). Few examine the consequences of disturbance-mediated declines in habitat quality. If disturbance represents an influential process

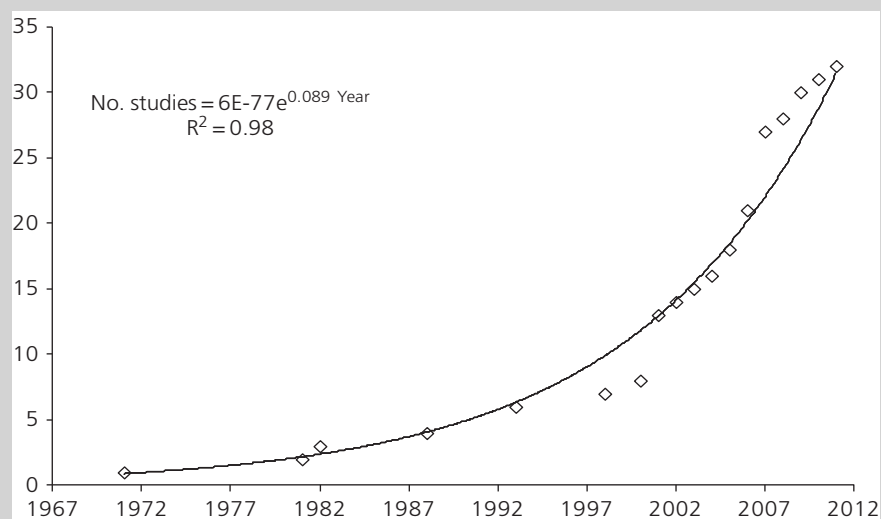


Figure 4.1 The cumulative number of 'major' studies of disturbance to birds and mammals that include dogs as a substantive stimulus, over time.

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Box 4.1 *Continued***Table 4.1** Selected 'major' studies of dog disturbance to wildlife presented in alphabetical order within group (bird or mammal). Criteria for inclusion are that studies involve dogs as a stimulus (directly, not indirectly via dog management zonation or incidental occurrence) and focus on the response and its impact on wildlife, present data, and are published in peer-reviewed journals. Similar articles are grouped.

Group	Study	Approach	Wildlife species	Predominant type of dog	Habitat	Country
Birds	Banks and Bryant 2007	Experimental	Bird assemblages	Leashed	Woodland	Australia
	Burger 1981; Burger et al. 2007; Lafferty 2001a, b	Observational	Coastal birds	Accompanied dogs	Marine shores	USA
	Dunbrack and Dunbrack 2010	Experimental	Glaucous-winged gulls and north-western crows	Closely accompanied	Open fields	USA
	Fernández-Juricic and Tellería 2000	Observational	Common blackbird	Accompanied	Urban parks	Spain
	Dowling and Weston 1999; Weston and Elgar 2005, 2007	Observational	Hooded plover (breeding)	Accompanied	Beaches	Australia
	Fitzpatrick, and Bouchez 1998; Kirby et al. 1993; Robinson and Pollitt 2002	Observational	Shorebirds	Accompanied	Coasts, estuaries, wetlands	UK
	Glover et al. 2011	Experimental	Shorebirds	Leashed	Coasts and wetlands	Australia
	Lafferty et al. 2006	Experimental	Coastal birds	Accompanied	Coasts	USA
	Lord et al. 2001	Experimental	New Zealand dotterel (breeding)	Leashed	Beaches	New Zealand
	Mallord et al. 2007	Observational and modeling	Woodlark	Accompanied	Heathlands	UK
	Miller et al. 2001	Experimental	Grassland and forest birds, plus one deer species	Accompanied (but one treatment where some separation from people occurred)	Forest	USA
	Murison et al. 2007	Observational	Dartford warbler	Accompanied	Heathlands	UK
	Randler 2006	Experimental	Eurasian Coot	Recording of barks	Wetlands	Germany
	Sastre et al. 2009	Observational	Great bustard	Accompanied and unaccompanied	Dry agriculture	Spain
	Taylor et al. 2007	Observational	Stone curlew	Accompanied	Fields (open access)	UK
Mammals	Cooper et al. 2008	Experimental	Eastern gray squirrel	Leashed	University campus	USA
	Gingold et al. 2009	Observational	Mountain gazelle	Guard dogs	Grassland	Jordan

continued

Box 4.1 *Continued***Table 4.1** *Continued*

Group	Study	Approach	Wildlife species	Predominant type of dog	Habitat	Country
	Hamr 1988	Experimental and observational	Alpine chamois	Leashed and unleashed	Alpine forests and pastures	Austria
	Kloppers et al. 2005	Experimental	Elk	Unleashed herding dogs	Urban, wetlands, forest	Canada
	MacArthur et al. 1982	Observational and experimental	Bighorn sheep	Leashed	Forest	Canada
	Mainini et al. 1993	Experimental	Marmot	Leashed	Alpine areas	Switzerland
	Manor and Saltz 2003, 2004	Observational	Mountain gazelle	Feral dogs	Coastal plain	Israel
	Martinetto and Cugnasse 2001	Experimental	Mouflon	Leashed and unleashed	Woodland and rocky	France
	Pelletier 2006	Observational	Bighorn sheep	Leashed and unleashed	Grassy slopes	Canada
	Sweeney et al. 1971	Experimental	White-tailed deer	Unleashed hunting dogs	Forests, pastures, cropland	USA

that degrades habitat quality, then it might be one of several ecological processes which effectively create 'ecological traps'; insidious situations whereby animals select habitat based on cues that no longer reflect actual habitat quality (Schlaepfer et al., 2002). For example, animals may select habitat on the basis of the presence of resources for foraging and breeding (e.g., the presence

of suitable hollows or prey), but may be unable to breed successfully because of disturbance while breeding. Such populations may represent attractive 'population sinks' (Schlaepfer et al., 2002). The episodic and extreme variation in human (and dog) presence in many areas means animals might settle in highly disturbed habitats during undisturbed periods.

4.2 Dogs as stimuli

The depth of evolutionary history and extent of wildlife interactions with wild canids have presumably shaped how wildlife perceive dogs, and the way dogs and wildlife behave during encounters (instances when wildlife and dogs interact). Canids may instinctively hunt wildlife and therefore dogs may be perceived as particularly threatening by wildlife (Gabrielsen and Smith, 1995). Among the diverse array of stimuli encountered by wildlife (e.g., humans, vehicles, predators, etc.), dogs as stimuli are associated with a specific set of features. First,

like other predators, dogs evoke some of the most dramatic responses among wildlife and are therefore apparently perceived as especially threatening (Weston and Elgar, 2007). Unlike benign stimuli, in which wildlife responses can be considered unnecessary (e.g., to recreationists on beaches), dogs are frequently 'non-benign' stimuli that often actively pursue wildlife during encounters, for example, by chasing (9% of dogs chased birds on a Californian beach, Lafferty, 2001b; 11.1% of disturbance to shorebirds on beaches around Mackay, Queensland, involved dogs chasing birds, Bloor, 2005). The

lack of an adequate response by wildlife may result in injury or death during such encounters. Dogs are associated with unique visual, auditory, and olfactory cues (e.g., shape, barking or howling, and scent marking) as well as more holistic cues such as posture, gait, and behavior. These cues may evoke responses among wildlife separately or in combination, however the specific canine cues (stimulus attributes) that are detected by wildlife and used to judge risk and inform response are unknown. Apparently, few studies test these cues separately, but it is unlikely that the visual cues are the only ones used to detect and assess risk by wildlife. Barking increases vigilance among preening Eurasian coots (*Fulica atra*; Randler, 2006), but apparently no information exists on disturbance by scent marking. Other native carnivores may respond to the scent of dogs on trails or in areas where dogs are allowed to roam freely, resulting in changes in activity in these areas (Lenth et al., 2008; Vanak et al., 2009).

4.2.1 Dogs as agents of disturbance

Several pieces of evidence suggest that dogs are prominent agents of wildlife disturbance, and that their role as agents of disturbance is often underestimated. First, experimental studies may underestimate dog disturbance. Most experimental studies of dog disturbance to wildlife mimic the most common types of stimuli because they seek management solutions and do not unravel specific aspects of a stimulus that cause disturbance. Studies of humans or other stimuli behaving as dogs do (e.g., by roaming) could enlighten as to whether it is dog behavior or dogs per se that contribute to the observed intense responses by wildlife (see Box 4.2). One key limitation of the current data available for dogs as an agent of disturbance to wildlife is the reliance on restrained dogs as experimental stimuli (Banks and Bryant, 2007; Faillace, 2010; Glover et al., 2011; Lord et al., 2001; Vanak et al., 2009). Thus, the most extreme wildlife responses may go unreported by experimental studies, while observational studies may better reflect the wildlife responses during more realistic encounters.

Second, dogs are among the most commonly encountered predator stimulus in at least some areas and circumstances (e.g., urban and recreational

parks and coasts; Antos et al., 2007; Butler et al., 2004; Scott, 1989; Underhill-Day and Liley, 2007). In some natural areas, walkers and dogs are the most common source of disturbance (response) recorded, such as in wetlands in the UK (Robinson and Pollitt, 2002). The frequency of dog encounters with wildlife probably stems from three main factors: (1) dogs are common companions of humans; (2) they are capable of roaming over large areas of habitat; and (3) they tend to be year-round residents. When unrestrained they can occupy larger parts of the wildlife habitats in which they occur compared to humans (Figure 4.2). The higher area of occupancy of owned dogs results from both the mobility of their owners and from dog 'roaming' (i.e., the distance they move from their owners). Dog walkers can be rather mobile; on the Thames Basin heaths, UK, the mean length of route for dog walkers was 2,500 m, more than walkers and picnickers (2,300 and 1,200 m, respectively), but less than joggers, cyclists, and horse riders (3,900, 4,900, and 3,200 m, respectively) (Underhill-Day and Liley, 2007). Unrestrained dogs roam within coastal habitats perhaps more than any other stimulus type (Coombes et al., 2008) except possibly predatory birds. They also roam in non-coastal habitats (e.g., Sastre et al., 2009), although in at least some areas their roaming has been regarded as more modest, perhaps because of low penetrability of thick trail-side vegetation (Bekoff and Meaney, 1997; Forrest and St. Clair, 2006; Mallord et al., 2007). Owned dogs, especially in urbanized societies, enjoy regular walks; for example, of 380 coastal residents in south-eastern Australia, 36.8% owned a dog of which 93.6% took their dog to the beach (Maguire et al., 2011a). This means dogs tend to be present in wildlife habitat year-round (Figure 4.3 provides an example of complete temporal overlap between unleashed companion dogs and a vulnerable life history stage of a sensitive wildlife species). For owned dogs, human social factors such as weekends and holidays influence their occurrence in many areas (Sastre et al., 2009), and presumably climate also dictates seasonality of occurrence, perhaps especially in higher latitudes. Resident village dogs are also often present year round, and presumably so too are free-ranging dogs. Despite the already high densities of accompanied dogs in many parts of the

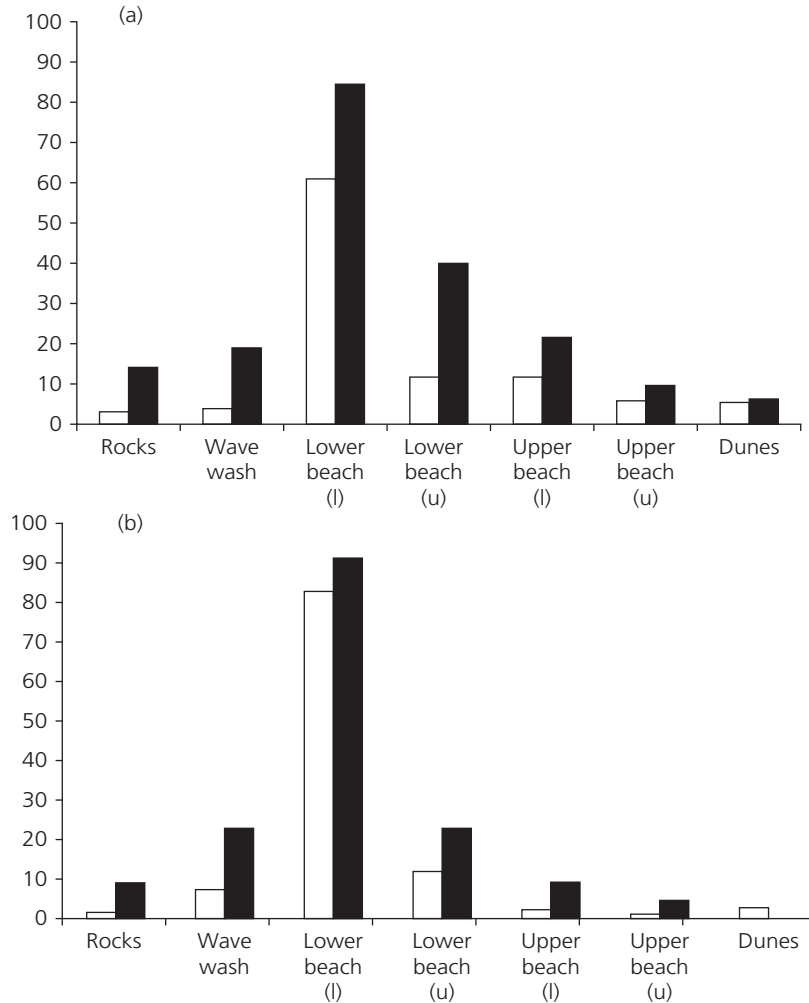


Figure 4.2 The habitat use of walkers (a, top panel) and joggers (b, lower panel) as they passed hooded plover (*Thinornis rubricollis*) nests on beaches in Victoria, Australia (see Weston and Elgar, 2007 for details; 'l' is the lower half, 'u' is the upper half) (unpublished data). The percentage of recreationists in each beach zone (averaged across nests) is shown. Open bars indicate that no dogs accompanied recreationists and closed bars indicate recreationists were accompanied by dogs off the leash. Walkers and joggers with dogs on leash were omitted due to small sample sizes.

world, projections suggest this activity will increase in future (Brickner, 2000); in some parts of the UK, 3.8–7.3% increases in dog walkers by 2080 are predicted (Coombes et al., 2008).

Finally, unrestrained dogs often move 'unpredictably' (i.e., their direction and speed varies frequently) and sometimes harass wildlife, traits that do not promote 'habituation,' the process whereby wildlife learn to reduce response intensities or frequencies with increasing exposure to a stimulus (Lafferty, 2001b; Sastre et al., 2009). Rather, these

attributes promote 'sensitization,' or enhanced response frequencies or intensities with increasing exposure to stimuli (Glover et al., 2011). Roaming (usually erratic central place movements around an owner) influences three factors used by many wildlife species to judge degree of threat: predictability (in behavior and to some extent occurrence), proximity, and speed (Glover et al., 2011). While some dogs roam without accompanying humans, many others are kept indoors or in yards, and roam during 'walks.' During walks, some highly trained

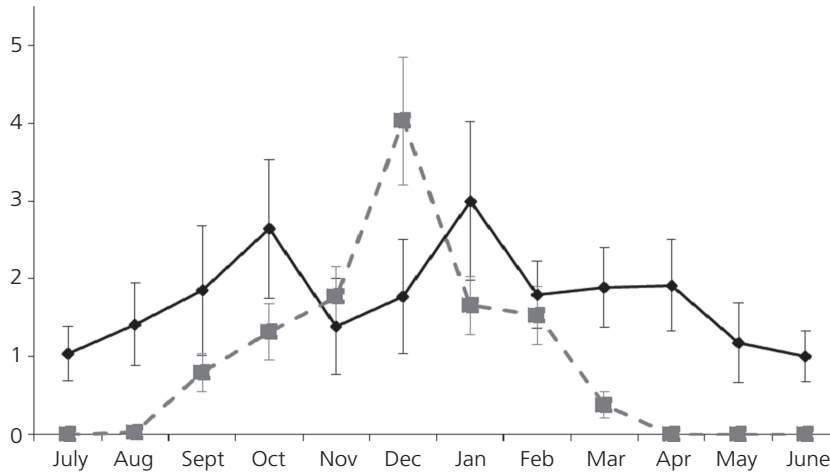


Figure 4.3 The average number of walkers with dogs off the leash (1,571 surveys of 69 beaches in Victoria, Australia, 1995–98; unpublished data; black lines) in relation to the average number of nests of hooded plover on those beaches (gray dotted line). Means and one standard error are shown; 6.1% of 743 dogs were leashed and are excluded from the graph.

dogs are effectively controlled by voice commands, but restraint in the form of a leash is by far the most common method of effectively managing dog roaming during walks. However, leashing rates are often low, with unleashed dogs apparently occupying more habitat than leashed dogs (Box 4.2).

4.2.2 Birds

A prerequisite for disturbance of wildlife is the temporal and/or spatial co-occurrence of stimuli and wildlife. The extent of overlap with wildlife populations and the frequency with which encounters occur is critical when judging possible impacts of disturbance. Birds probably frequently encounter dogs, though information on encounter rates (i.e., where an interaction is possible) is limited mostly to parks and beaches (see Section 4.2.1), where dogs are reported as the most, or among the most, frequently occurring stimuli (Antos et al., 2007; Mallord et al., 2007). While these studies often focus on recreational disturbance, and thus presumably present a biased ‘heavily disturbed’ sample, the potential for conflict between dogs and birds is high. Some information is available on the occurrence of dogs in or near bird habitat, and that information, while restricted to urban and wetland areas, suggests dogs are common sometimes even

in ‘off-limits’ nature reserves dedicated to bird conservation (e.g., 8.5 times per weekend day; Antos et al., 2007). The hooded plover, a threatened beach-nesting shorebird, experiences many natural and anthropogenic stimuli on Victorian beaches, Australia, where 18–19% of encounters with nests or broods involved dogs, at a rate of 0.47 encounters per hour (Weston and Elgar, 2005, 2007). Off-leash dogs and dogs chasing birds were the third and fourth most common causes of disturbance to shorebirds around Mackay, Queensland (Bloor, 2005). Dogs accompanying people were the third most common stimulus causing flushing among blackbirds *Turdus merula* in urban parks in Madrid, Spain (Fernández-Juricic and Tellería, 2000). Of all stimuli encountered by roosting shorebirds on the Dee Estuary, UK, 1986–91, 26–41% involved dogs (Kirby et al., 1993). Little information is available on encounter rates between unattended dogs and birds; in Madrid unattended dogs represented 1.3% of potentially disturbing activities for great bustards (*Otis tarda*; Sastre et al., 2009), and on Victorian beaches, unattended but apparently owned dogs represented 0.9% of stimuli passing hooded plover nests (Weston and Elgar, 2007).

Not all birds are threatened by dogs in the same way or to the same extent, so the perception of dogs as threatening probably varies taxonomically (see

Box 4.2 Leashing as a tool to reduce roaming

'Leashing' refers to the attachment of a tether to a collar or harness on a dog to control the dog's movements in relation to a mobile human. Leashing is considered the most effective way of reducing harmful dog–wildlife interactions in areas where pet dogs are exercised in areas where they may encounter wildlife. It is often considered more effective and enforceable than 'effective control' (e.g., through voice commands), which are difficult to measure and enforce.

Leashing presumably reduces wildlife responses (e.g., Weston and Elgar, 2005) by reducing dog roaming rather than the presence of a leash per se. Thus, there is presumably a maximum leash length that effectively reduces the roaming of dogs to the point where most wildlife decrease their responses (this is likely to vary between species; Glover et al., 2011). A review of commercially available leashes on the Internet reveals a significant difference in length of different types of leashes ($n = 58$, Kruskal Wallis = 38.83, $p < 0.001$). Traditional, commercially available, leashes constrain dogs to within 1–2 m of their owners, though retractable leashes are longer (typically 5–8 m in length) and some non-retractable leashes are up to 15 m in length (Figure 4.4). As leashing laws have become more prevalent, and with the advent of retractable (longer) leashes, it seems likely that, on average, leash length has increased over time.

Despite a great variety of leashing options, in at least some areas, the majority or at least a substantial proportion of dogs are unrestrained. For example, on Australian (90%

unleashed, Weston and Elgar, 2005; Williams et al., 2009) or US beaches (93%, Lafferty, 2001b), including areas where dogs are not permitted off-leash or at all, such as national parks (88%, 1991–98, Dowling and Weston, 1999; Arnberger et al., 2005), recreation reserves (22%, Austria, Arnberger and Eder, 2008), wetland reserves (100%, Antos et al., 2007) and buffers (68%, Weston et al., 2009). In heathland sites (UK), generally most or all dogs were unleashed (92%, Mallord et al., 2007; Underhill-Day and Liley, 2007). Thus, in at least many parts of the world, wildlife most frequently encounter free-ranging dogs regardless of prevailing local regulations (Lafferty et al., 2006). Miller et al. (Chapter 12) discuss the decisions made by owners in relation to leashing.

Although there have been virtually no studies, leashing appears to constrain dog roaming, at least in habitats where dog roaming is not constrained by vegetation or other impediments to movement. For example, on beaches in Victoria, Australia, where active hooded plover nests occurred, walkers and joggers accompanied by unleashed dogs occupied more levels of the beach than walkers or joggers without dogs (Figure 4.2). Walkers and joggers without dogs occupied fewer beach zones compared with when their recreational group (people and dogs) included unleashed dogs (walkers, 1.0 versus 2.0 beach zones occupied respectively (medians), $n = 1081$, $U = 21.69$, $p < 0.001$; joggers, 1.0 versus 1.5 zones, $n = 161$, Kruskal Wallis = 28.25, $p < 0.001$).

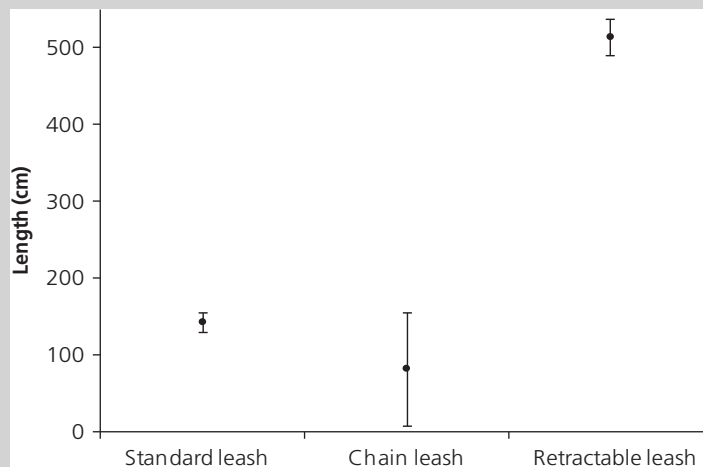


Figure 4.4 The length of commercially available leashes for dogs (not puppies; in cm), as revealed by an Internet search of several major pet supply stores ($n = 58$ products). Standard leashes are made of nylon or leather. Means and 95% confidence intervals are shown. Two 'recall' leashes (9 and 15 m) and leash extenders (up to 1 m) are excluded.

also Box 4.3). Many birds use trees, cliffs, open water, or spend much of their lives on the wing; such species are presumably immune or buffered from any negative impacts of dogs, and it might be predicted that dogs are not perceived as especially threatening by these species (but see Banks and Bryant, 2007). Dogs sometimes enter waterbodies where they can disturb waterbirds (Kramer, 1986). However, flightless species or those that become flightless when molting, ground-dwelling, and especially ground-nesting birds are most likely to interact with dogs, and have been the subject of most research on dog–bird interactions. In this way, there may be a bias in existing literature, whereby the species most vulnerable to negative interactions with dogs may have been documented most. Nevertheless, bird–dog “conflicts” are reported from around the world.

4.2.3 Mammals

Unlike birds, where for some species researchers can monitor all disturbances for a group of birds over an extended period of time, encounter rates between wild mammals and dogs are less evident. In regions where dogs primarily travel with owners, the rate at which mammals may encounter dogs should be positively related to their distance from restricted trails where leashed dogs may occur and the prevalence of dogs off-leash in the area. Accompanied dogs, however, are typically found in recreational areas during daylight hours, while many mammals are nocturnal, reducing the potential for direct encounters. Free-ranging dogs, however, tend to be nocturnal and show great variation in their home range sizes (from 1 ha up to about 2,500 ha) with potentially much greater disturbance effects on wild mammals (Meek, 1999). Unlike birds, which typically have the option to fly away, most mammals (excluding bats, aquatic, semi-aquatic, and arboreal mammals) are limited to terrestrial escape and are, therefore, more greatly affected by the tendency for dogs to roam widely across a landscape. While most types of dogs are better chasers than they are efficient hunters (cf., dingoes), they are able to capture and kill a variety of mammals (see Ritchie et al., Chapter 2)

and generations of selective breeding have provided subsets of dogs with specialized traits favorable for hunting, locating and capturing prey, fighting, and racing (Serpell, 1995). Trained hunting dogs can induce prolonged disturbance bouts. Sweeney et al. (1971) found that hunting dogs ($n = 65$) chased white-tailed deer (*Odocoileus virginianus*) for an average of 33 min (up to 155 min) and an average of 3.9 km (up to 21.6 km). While no mortality occurred during these chases, 78% of the experimental chases resulted in the deer leaving their home range, with most returning within a day. While these were controlled experimental cases, untrained free-ranging dogs have much greater home range sizes (Meek, 1999) and should, therefore, be more likely to initiate long chases and move wildlife from their own home ranges. Unleashed dogs on beaches may be particularly dangerous for marine mammals. Several studies report harassment and killing of harbor seals (*Phoca vitulina*; Allen et al., 1984) and Hawaiian monk seals (*Monachus schauinslandi*; Gerrodette and Gilmartin, 1990; Kenyon, 1972) by dogs, suggesting that uncontrolled dogs could be particularly detrimental to populations of pinnipeds, which move slowly and awkwardly on land. Clearly, the impact of free-ranging dogs is a function of breed, training, past experiences with wildlife, and the prey encountered. Ultimately, dogs can prey upon a wide variety of wild mammals, including terrestrial (e.g., hedgehogs *Erinaceus europaeus*; Doncaster, 1994), arboreal (Lumholtz’s tree-kangaroos *Dendrolagus lumholtzi*; Newell, 1999), and marine mammals (Allen et al., 1984; Barnett and Rudd, 1983), thus mammalian responses to dogs are expected to be substantial.

Wild mammals (perhaps except very large herbivores or carnivores) may alter their spatial distribution in areas where dogs are permitted to roam to reduce the likelihood of encountering potentially dangerous canines. Lenth et al., (2008) studied signs of mammal activity nearby and far from trails in parks where leashed dogs were permitted on-trail and in parks where dogs were prohibited. They found lower signs of activity of mule deer (*O. hemionus*), rabbits (*Sylvilagus* spp.), prairie dogs (*Cynomys ludovicianus*), and other small mammals

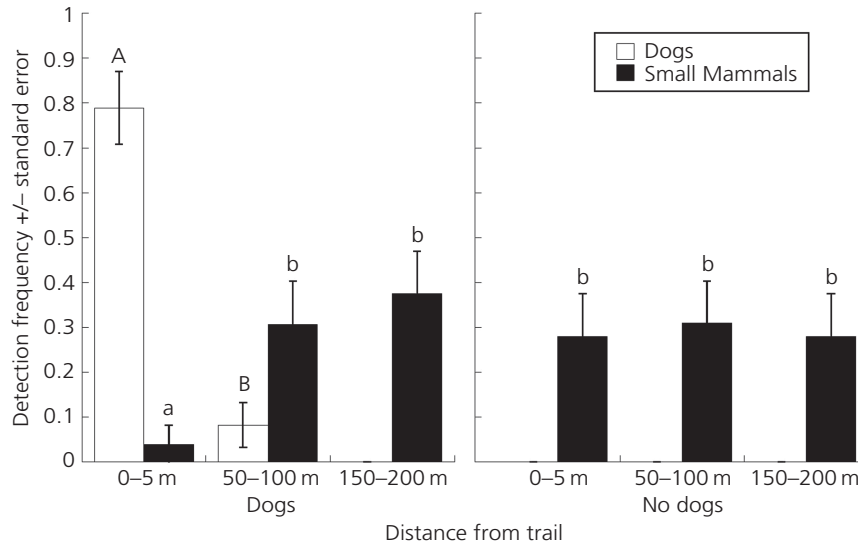


Figure 4.5 Detection frequencies of dogs and small mammals on track plates at different distances from trails where dogs are permitted or prohibited in a natural area. Different uppercase letters above columns indicate significant differences ($p < 0.1$) in dog detection frequencies, and different lowercase letters indicate significant differences ($p < 0.1$) in small mammal detection frequencies. Redrawn and reprinted with permission from the Natural Areas Association from Lenth et al., (2008).

on trails where dogs were permitted, compared to dog-free trails (Figure 4.5). Native carnivore activity, however, was higher near the end of trails where dogs were permitted but lower near trail heads, suggesting that carnivores avoided dog cues when abundant (i.e., trail heads) but may be attracted to them as novelty when they are present but rare (i.e., ends of trails). Bobcats (*Lynx rufus*) avoided dog trails altogether, perhaps because of the similarity between dog cues and those of coyotes (*Canis latrans*), a natural potential predator (which showed no difference in activity between sites). Similarly, mesocarnivores tend to avoid areas of high dog activity; bobcats (George and Crooks, 2006) and Indian foxes (*Vulpes bengalensis*) (Vanak and Gompper, 2010) showed reduced activity in areas where dogs were most active.

4.2.4 Other vertebrates

Comparatively little information is available on the role dogs play as stimuli for non-avian or non-mammalian vertebrates (henceforth 'other vertebrates'). In addition to visual, auditory, and olfac-

tory cues, some reptiles (e.g., snakes) also perceive vibrations in the ground associated with the approach of a threat (Young, 1983).

In many terrestrial areas, there is probably substantial temporal and spatial overlap between other vertebrates and dogs, though the extent of any interaction is virtually undocumented. Despite this, dog disturbance and 'harassment' is considered a conservation problem for amphibians and reptiles (e.g., British Columbia Government, 2004). While dogs have been present in many habitats for millennia, in some habitats they are relatively new arrivals, and have quickly established themselves as predators, and agents of disturbance, of vertebrates apart from birds and mammals. One example is on the Galapagos Islands, where marine iguanas (*Amblyrhynchus cristatus*), isolated from terrestrial predators for 5–15 million years, apparently first encountered dogs on some islands only *ca.* 150 years (Berger et al., 2007). The increase in dogs (and cats) has coincided with human settlement in the islands and now causes disturbance and mortality among iguanas.

Box 4.3 Persecutor to protector; dog disturbance protecting wildlife

Not all dog–wildlife disturbance results in negative outcomes for wildlife. Dogs also disturb pest and nuisance species, and in circumstances where wildlife are more tolerant or less vulnerable than pests, or where dogs are trained specifically to defend wildlife, then dogs essentially become their protectors. Additionally, disturbance can be used as a non-lethal alternative to achieve management objectives that reduce human–wildlife conflict, and so effectively benefit wildlife.

In urban backyards of some Australian cities, the presence of pet dogs decreases the probability of denning by the introduced pest species, the red fox (*V. vulpes*; Marks and Bloomfield, 2006). This presumably permits a variety of wildlife to persist which otherwise could not. Carefully trained guard dogs defend a handful of threatened species or significant wildlife colonies (e.g., burrow and surface nesting seabirds) against introduced or problematic predators (van Bommel, 2010); in the same way they can defend stock against predators and so reduce farmer–wildlife conflict (Coppinger et al., 1987; VerCauteren et al., Chapter 9). Some airports use dogs to reduce bird hazards to aircraft as a non-lethal management alternative (Froneman and van Rooyan, 2003). Dogs have even been used as aversive conditioning stimuli to dishabituate elk *Cervus canadensis* and other ungulates in areas where they are heavily encroaching on human settlements (Kloppers et al., 2005; VerCauteren et al., 2008; Walter et al., 2010). In these cases, dogs of different breeds

have been effective hazing tools for wildlife managers. Livestock and crop protection dogs have also been used to chase away wild ungulates from cattle ranches (thereby limiting the spread of zoonoses like brucellosis to cattle), golf courses, orchards, and forest plantations (VerCauteren et al., 2005, 2008; Walter et al., 2010); and breeds that are territorial and patrol open spaces (e.g., Siberian Husky, Alaskan Malamute) have been most effective (VerCauteren et al., 2005).

Finally, the ability of dogs to detect wildlife that would be otherwise undetectable, often by honing in on their scent and evoking a flight reaction, has supported the conservation effort of many cryptic species such as kiwi (*Apteryx australis*) in New Zealand (Taborsky, 1988), black grouse (*Tetrao tetrix*) in England (Baines and Richardson, 2007), or Mojave desert tortoises (*Gopherus agassizii*) in the USA (Heaton et al., 2008). This ability to locate cryptic wildlife can be harnessed to capture individuals for their use in threatened species programs or to survey sites to assess their suitability for human development, or general wildlife surveys (Gutzwiller, 1990; Woollett et al., Chapter 10). Additionally, dogs have played a critical role in pest eradication aimed at ecological restoration, such as in the attempts to eradicate European rabbits (*Oryctolagus cuniculus*) from the sub-Antarctic Macquarie Island (Australian Government, 2012). Such efforts cause short-term disturbance but can result in long-term beneficial conservation outcomes.

4.3 The response of wildlife

Disturbance responses among wildlife are generally accepted to have evolved as anti-predator responses, and are adaptive among populations exposed to predators. Wildlife responses to dogs range from vigilance and crypsis to active defense such as aggression or flight, and are adjusted in relation to a range of internal and external factors (Glover et al., 2011). Optimal escape theory posits that responses can be considered in a cost–benefit framework, whereby escape entails costs (often energetic costs) but delivers benefits (notably enhanced survival) (Ydenberg and Dill, 1986), and in an optimality framework, whereby escape permits gain of fitness after the interaction whereby death leads to loss of all future fitness (Cooper and Frederick, 2007, 2010).

Based on differential responses, wildlife have the capacity to discriminate between stimuli, including discriminating between dogs and other stimuli (Glover et al., 2011; Lord et al., 2001). Given all wildlife have to respond to threatening stimuli in some way, a key question is how response rates or intensities in relation to dogs compare with those caused by other stimuli, natural or anthropogenic.

Many studies of disturbance report wildlife responding frequently and substantially to dogs, despite at least many decades, if not centuries or millennia, of exposure. Wildlife responses are likely to be shaped at two distinct time-scales: within lifetimes and over evolutionary time. Changes to responses within lifetimes are driven by learning, that is altered responses on the basis of individual

experience. The persistence of responses in circumstances where the stimuli do not apparently represent substantive threats (i.e., to human recreationist) suggests that habituation, if it occurs, is often modest (Glover et al., 2011). Responses will also have been shaped by evolution. Continuing (apparently costly) responses of wildlife to dogs, despite long-term exposure, presumably mean that such responses are adaptive, in other words, the avoidance of dog predation despite the cost of responses has presumably conferred fitness benefits. In many places (such as Europe and North America) dogs

may be considered as functional analogs, albeit at elevated densities, of now-extinct or rare predators such as wolves *C. lupus*; in other areas (such as New Zealand and many other islands) mammalian terrestrial predators are evolutionarily novel. This creates an interesting paradox (Figure 4.6); among wildlife which is evolutionarily 'better-prepared,' dog-related disturbance may sometimes be higher (and yet levels of predation lower) than in areas with largely naïve native faunas, where disturbance may be relatively modest but predation levels high (e.g., Berger et al., 2007).

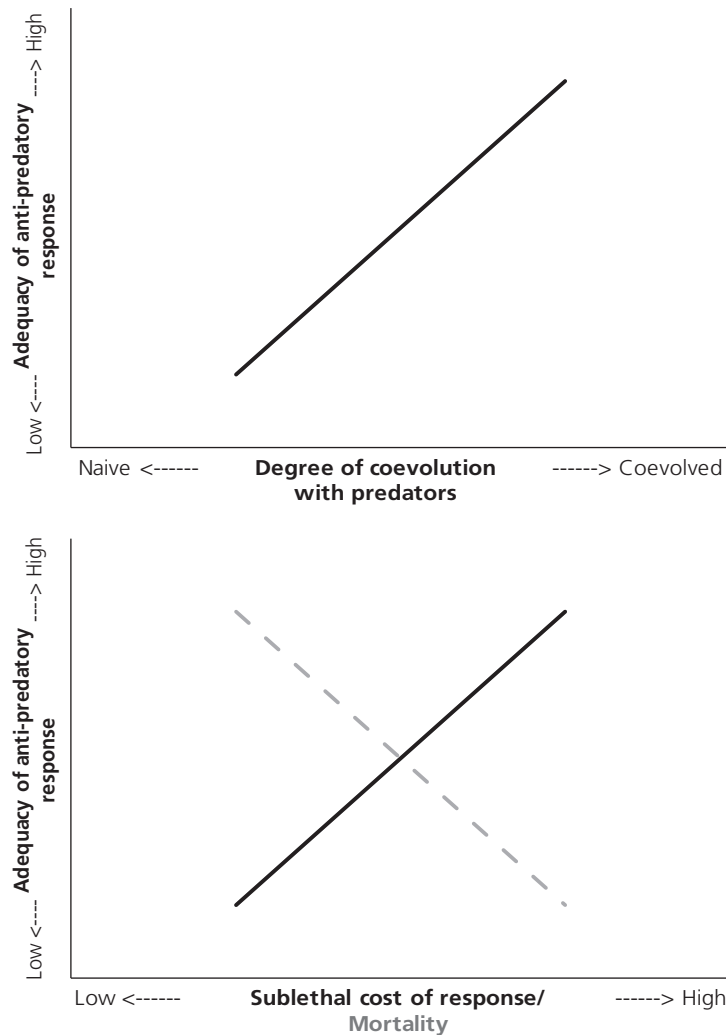


Figure 4.6 Diagrammatic representation of a conceptual model of the 'Disturbance–Predator Paradox.' Evolutionarily naïve species may not exhibit strong anti-predator responses (top panel) which means they may not incur substantial sublethal costs from maladaptive responses to benign stimuli. However, they may experience high mortality when stimuli are not benign (bottom panel). Black solid lines indicate sublethal effects; dashed gray lines indicate lethal effects.

4.3.1 Birds

Birds flee dogs—on foot, on the wing, by climbing, swimming, or diving. One measure of response intensity is Flight Initiation Distance (FID), the distance at which an animal flees from an approaching stimulus. Apart from flight (fleeing) a variety of responses are given to dogs. These include vigilance, absences from nests or young, distraction, and reductions in, or cessation of, foraging (Colwell and Sundeen, 2000; Weston and Elgar, 2005, 2007). Aggression is also reported, with aggressive ground- (e.g., lapwings, *Vanellus vanellus*) and tree-nesting species (e.g., Australian magpies, *Gymnorhina tibicens*) swooping some dogs (M.A. Weston, unpublished data). These responses are all associated with energetic and other consequences, which are generally poorly known and require more study.

Observational studies report higher response rates or intensities of ground-nesting birds to unleashed dogs over other anthropogenic stimuli, although naturally occurring stimuli may still evoke more frequent or longer lasting responses (Burger, 1981; Taylor et al., 2007; Weston and Elgar, 2005; 2007). Walkers accompanied by dogs often evoke greater responses in ground-dwelling birds than humans alone (Lord et al., 2001; Sastre et al., 2009; Sime, 1999). For example, stone curlews (*Burhinus oedicanus*) show FIDs to dog walkers that sometimes exceed 500 m (Taylor et al., 2007). Dogs caused higher rates of flushing at prairie chicken (*Tympanuchus cupido*) leks compared with visits by foxes (Hamerstrom et al., 1965). Few studies of the response of birds to unattended dogs are available, but those results that are available suggest that the degree to which dogs unaccompanied by people disturb birds is context specific. Unattended dogs in steppes around Madrid represented 1.3% of potentially disturbing stimuli for great bustards, but caused 2.9% of responses; the probability of causing a disturbance was higher for dogs than for any anthropogenic activity recorded, including hunting, vehicles, and aircraft (Sastre et al., 2009). On the other hand, two grassland birds in the USA (vesper sparrows, *Poocetes gramineus*, and western meadowlarks, *Sturnella neglecta*), were disturbed least by unattended lone dogs, and more so by walkers and walkers with dogs (Miller et al., 2001). Perhaps the

height of an approaching stimulus alters the distance at which stimuli are detected, especially where lower strata, such as grass, limit the field of view.

Observational studies of disturbance to birds have focused on attended dogs, usually on coasts, wetlands, or in parks, and have demonstrated that dog–bird interactions are common worldwide, and that birds respond frequently and substantially to dogs. Walkers and dogs were the most common source of disturbance recorded at coastal and inland wetlands in the UK, although they were more likely to cause disturbance to waterbirds at coastal sites, probably because of the nature of the habitats and the degree of spatial overlap between human activities and birds (Robinson and Pollitt, 2002). On the Dee Estuary, UK, 1986–91, dogs caused high rates of disturbance to shorebirds (27–72% of all disturbance events) compared with walkers (20–34%), even though walkers were more commonly encountered (Kirby et al., 1993). On the other hand, dogs did not influence vigilance rates of shorebirds foraging on a rocky beach at Belfast Lough, UK (Fitzpatrick and Bouchez, 1998). On a beach in Santa Barbara, California, 10% of humans and 39% of dogs disturbed birds (Lafferty, 2001a). On beaches around Mackay, 14.8% of all disturbances to shorebirds (involving 24.6% of shorebirds present) were caused by dogs (birds flew up to at least 250 m; Bloor, 2005). Dogs were the most common cause of disturbance to breeding Dartford warblers (*Sylvia undata*) in heathland sites in Dorset, UK (Murison et al., 2007). At Esquimalt Lagoon, Canada, dog walking caused 18% of observed anthropogenic disturbances to waterbirds (Clowater, 2008). Observational studies such as these have underpinned the perception among managers that dog disturbance of wildlife is a high priority for management (Le Corre et al., 2009). While observational studies map the occurrence of stimuli and response in space and time, they don't unravel the specific stimulus–response–consequence mechanisms that permit deeper analysis of the issue. The consequences of disturbance responses are not obvious at the individual level, let alone the population level. For example, it is generally unknown how the rate or intensity of response is associated with fitness, and whether the relationship is linear or nonlinear, with or without 'thresholds.'

Several experimental studies of wildlife disturbance explicitly investigate the influence of stimulus type on response (reviewed in Weston et al., 2012) but very few use dogs as one of the stimuli tested. Glover et al. (2011) showed that of eight shorebirds tested, stimulus type (walker, jogger, walker with leashed dog) significantly influenced FID of three species. Excluding joggers, all three species had highest FID when approached by a person with a leashed dog, rather than by a person alone. Snowy plovers (*Charadrius alexandrinus*) react at twice the distance to dogs than to pedestrians (Fahy and Woodhouse, 1995; Lafferty, 2001b), and disruptions to incubation caused by investigator approaches to northern New Zealand dotterel (*C. obscurus aquilonius*) nests were longer when a leashed dog was present (Lord et al., 2001). North-western crows (*Corvus caurinus*) and glaucous-winged gulls, (*Larus glaucescens*) took bread at greater distances from a human and dog than from a human alone, reversing the outcome of food competition between these species (Dunbrack and Dunbrack, 2010).

Other measures of response include the amount of time before the resumption of normal activities. Similar to the New Zealand dotterel, snowy plovers remained away from their nests for longer durations when a walker with a leashed dog approached, compared with a walker alone, on one Florida island (although not on another) (Faillace, 2010). A variety of internal and external factors influence response rates to stimuli, and these presumably also apply to responses of birds to dogs. Body mass, wing shape, diet, age, sex, group size, experience including geographical isolation from predators, personality, site attributes including distance from cover and the presence of barriers such as fences or canals, whether stimuli occur on- or off-trail, and weather, among other things, may influence responses (see Stankowich and Blumstein, 2005; Weston et al., 2012). There will also doubtless be attributes of dogs that alter response, potentially including size and personality (reflecting breeds in some cases), group size, vocalizations, propensity to roam, age, and so on. Habitat mediates the responses of some birds, perhaps because some habitats are impenetrable to dogs (Mallord et al., 2007; Robinson and Pollitt, 2002). In forests, the American robin (*Turdus migratorius*) responded similarly to walkers

alone and those accompanied by a dog, while two grassland species responded more strongly when a walker with a dog approached (Miller et al., 2001). Thus, it is possible that habitat mediates the responses of birds to dogs.

4.3.2 Mammals

Many studies have measured the direct disturbance effects of human recreation on wild mammals (see Knight and Gutzwiller, 1995; Stankowich, 2008; Stankowich and Blumstein, 2005). Mammals typically respond to dogs by fleeing to a burrow or tree, but larger mammals that lack these options often escape over long distances and are more likely to be displaced from their home range, stressed physiologically, and experience the negative effects of escape for longer durations. As a consequence, ungulates have been a common focus of disturbance studies, especially in response to dogs. Generally, the presence of a human has a greater impact on wildlife behavior in areas with relatively low human density, and one explanation of this is the possibility that animals habituate to humans in a non-threatening context (Stankowich, 2008). The effect of dogs relative to humans is less clear. While some studies find wild mammals to be less fearful of humans alone compared to humans accompanied by dogs (e.g., Hone, 1934), others have observed that mammals responded in the same manner irrespective of the presence of dogs (e.g., Hamr, 1988). While the most common response to the presence of a dog is to become alert and flee, the presence of dogs may also alter physiological responses. Bighorn sheep (*Ovis canadensis*) had greater heart rates when approached by a human with a dog compared to a human alone (MacArthur et al., 1982) and domestic sheep (*O. aries*) showed greater fear and avoidance of a dog compared to a human or a goat (Beausoleil et al., 2005). The presence of dogs during captures by wildlife managers may exacerbate these physiological effects (Sime, 1999). Marmots (*Marmota marmota*) were more likely to flee to burrows and to emit warning whistles, and they took longer to re-emerge from burrows after escape when dogs were present with humans, compared to humans alone (Figure 4.7). Interestingly, in some cases, the presence of a dog may actually reduce the degree of response altogether (where

'degree of response' refers to the level of behavioral response in a typical hierarchy of responses that escalate with increasing risk). Eastern gray squirrels (*Sciurus carolinensis*), in the presence of a dog compared to a human alone, tended to run *less* often and were more likely to freeze, erect, or flick their tails (Cooper et al., 2008). In addition to these immediate reactions to the presence of dogs, some species may increase their group size to gain protection. Mountain gazelles (*Gazella gazella*) had larger group sizes in areas with more feral dogs (Manor and Saltz, 2003), which prey on gazelle neonates, and the culling of feral dogs significantly increased the kid:female ratio in subsequent years (Manor and Saltz, 2004).

Wild mammals may be more attuned to dogs as potential predators, and in their presence may have a greater zone of awareness (the bounds of which are the maximum distance at which an animal will become alert and monitor a potential predator; Stankowich and Coss, 2006). Marmots became alert to trail hikers led by dogs and hikers with free-ranging dogs at significantly greater distances than to off-trail hikers or trail hikers without dogs (Mainini et al., 1993), but there was no difference between leashed and free-ranging dogs. Mule deer were more likely to become alert, and became alert at greater distances, when hikers were accompanied by leashed dogs off-trail compared to when hikers were alone (Miller et al., 2001). While

the presence of a dog with a hiker elicited greater alert distances from eastern gray squirrels in areas with high human activity, interestingly, there was no corresponding effect in areas of low human activity, where alert distances were much greater for both types of stimuli (Cooper et al., 2008), suggesting that wild mammals may have an easier time habituating to humans when they are common, but dogs will always be perceived as dangerous regardless of their ubiquity.

The decision to flee is based on a substantial array of factors, including past experience with the stimulus type (i.e., learning effects), the type of stimulus (i.e., predator identity), and threatening behavior of the stimulus (e.g., approach speed, directness) (Stankowich, 2008; Stankowich and Blumstein, 2005). Therefore, it is predicted that, similar to alert distances, animals should flee from more threatening stimuli at greater distances than less threatening stimuli. Indeed, marmots fled from hikers with leashed or free-ranging dogs at greater distances than hikers without dogs, but, again there was no difference between leashed and unleashed dogs, although the minimum FIDs in response to off-leash dogs were much greater than for leashed dogs (Figure 4.7). Identical results were found for mouflon (*O. musimon*; Martinetto and Cugnasse, 2001) and mule deer also had a greater probability of fleeing and a greater FID in response to hikers with a

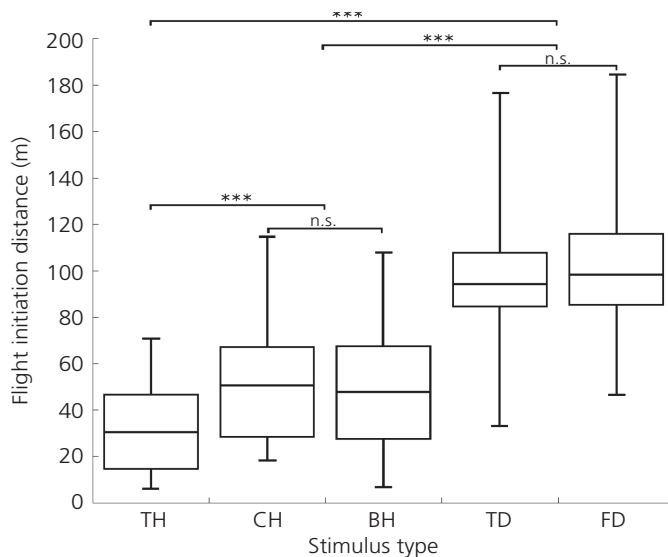


Figure 4.7 Flight initiation distance (median, IQR, min., max.) of marmots in response to people hiking on marked trails (TH), hikers walking cross-country off trails (CH), people hiking off trails across burrows (BH), people hiking on trails with leashed dogs (TD), and people hiking off trails with dogs on a 10 m leash to simulate free-ranging dogs (FD). $n = 20$ for each stimulus; *** $p < 0.001$. Redrawn and reprinted with permission from Elsevier from Mainini et al., (1993).

leashed dog, compared with hikers without dogs (Miller et al., 2001). Interestingly, elk fled at similar distances to humans alone and humans accompanied by dogs, both before aversive conditioning (experimental harassment by humans and dogs) and afterwards (Kloppers et al., 2005). This population, however, was highly habituated to humans and was encroaching on a settlement prior to conditioning, so the generality of this result is questionable. Finally, due to thousands of years of co-evolution with other wild canids, wildlife escape responses to dogs may be influenced by subtle behavioral cues shared by hunting canids: caribou (*Rangifer tarandus*) herds allow wolves to approach closely until they recognize behaviors indicating the wolves' intentions (Bergerud, 1974).

Once an animal has fled, the distance they move from the source of disturbance may also be an indicator of the perceived threat of the disturbance, however, results are conflicting. Similar to the findings for FID and alert distance noted above, bighorn sheep fled similar distances in response to humans with leashed dogs in comparison with free-ranging dogs (Pelletier, 2006). While mule deer tended to flee greater distances when humans approached with dogs off-trail compared to humans without dogs, they found no such difference on-trail (Miller et al., 2001). In contrast, alpine chamois (*Rupicapra rupicapra*) that haven't been exposed to wolves for many generations, were more curious of trained stationary dogs; and when unaccompanied-but-trained dogs were allowed to pursue, chamois fled shorter distances compared to humans alone but defended themselves with horns if overtaken and cornered (Hamr, 1988). Given these results, it appears that the distance that wild mammals move in response to dogs may depend more upon their past experiences with them and the landscape in which the encounter occurs.

Being on or off trail influences many wildlife responses to dogs (Mainini et al., 1993; Miller et al., 2001), but many other factors may mediate fright responses. Larger group sizes may ameliorate physiological effects on mammals of dog presence and increase perceptions of safety; MacArthur et al., (1982) found a negative association between group size and heart rate in mountain sheep when humans approached with a dog but not when humans approached with-

out a dog. Many seasonal differences influence the response of wildlife to dogs, including difficulties of escape in snow, over rugged terrain, or when accompanied by offspring (Sime, 1999; Stankowich, 2008). As the effects of the presence of dogs during human-mammal encounters have received little attention, other interacting effects have yet to be studied, although they likely include past experiences of wildlife with dogs or other wild canids, human density in the area, size and defensive ability of the wildlife species, and the availability of, and distance to, refuge.

4.3.3 Other vertebrates

Reptiles and amphibians are preyed on by dogs (e.g., Koenig et al., 2002), so it is unsurprising that they respond to the presence of dogs. They respond to disturbance by fleeing on land or in water, climbing, and often use refuges, for example in crevices or vegetation. Snakes may defend themselves against dogs by rearing and striking, resulting in a much publicized dog-wildlife interaction, which is often characterized in the media as 'snake attacks' (e.g., Levy, 2011), but which are more likely to be an aggressive defensive response to the approach of a dog. Snake bites of dogs occur worldwide; 44% of domestic animals in Australia suffering from snake bites, and which were presented to veterinarians, were dogs ($n = 1590$; Mirtschin et al., 2008).

While escape behavior in reptiles, usually running, has been used as a general model of developing and testing theoretical frameworks for flight (e.g., Cooper and Wilson, 2007), little information is available of the response of reptiles to the presence of dogs. Mojave Desert tortoises (*Gopherus agassizii*) did not alter their movement patterns when detected by dogs as opposed to by a person without a dog (Heaton et al., 2008). Marine iguanas on islands with free-ranging dogs (and cats) exhibited higher FIDs in response to human approaches and human chasing and had higher corticosterone levels than those on islands without dogs (Berger et al., 2007). The species is capable of habituating to human disturbance, but dogs are an actual predator (i.e., a non-benign stimulus) so responses are likely to be adaptive, although currently they are not effective at avoiding predation (Berger et al., 2007; Rödl et al., 2007). Blue-tongued lizards (*Tiliqua scincoides*)

may persist in suburbia, partly because their use of hard cover refuges in response to threats may avoid predation by dogs (Koenig et al., 2001).

We were unable to locate any literature on dog disturbance of amphibians, though fleeing, cypsis including the cessation of calling, and other responses are expected.

4.4 The impacts of dog disturbance on wildlife

The question as to whether disturbance is a welfare and/or a conservation issue is critical to the way dogs should be managed in natural areas. Management priorities may not include mitigating disturbance unless it is perceived to be a conservation risk. Once again, the most studied impacts of disturbance by dogs on wildlife involve coasts and parks, and owned dogs.

4.4.1 Birds

Disturbance represents a conservation threat if it negatively influences wildlife population viability. Population parameters that influence viability include average reproductive success, recruitment, survival, and habitat use. Most evidence of deleterious impacts of dog disturbance derives from readily measured behavioral responses, which involve the disruption of critical behaviors such as compromised parental care (Weston and Elgar, 2005, 2007). A few findings infer that such disruption can affect key population parameters, such as through depressed reproductive success. For example, effective dog management zones are associated with higher reproductive success among hooded plovers (Dowling and Weston, 1999).

Only a handful of studies link population or community level impacts of disturbance, and even fewer focus specifically on dogs as agents of disturbance. An increase in recreational disturbance, which mostly constituted dog walkers and unleashed dogs in heathland sites at Dorset, UK, resulted in a 17% decrease in breeding productivity of the ground-nesting woodlark (*Lullula arborea*). A range of access scenarios indicated that a doubling of current recreational levels does not apparently influence the woodlark breeding population size, but a more evenly distributed occurrence of

recreationists would impact populations substantially (Mallord et al., 2007). Little direct evidence is available to link dogs with altered usage of habitat. In an Australian woodland park, there was a 35% reduction in bird diversity and 41% reduction in abundance due to the presence of leashed dogs, both in areas where dog walking is common and where dogs are prohibited (Banks and Bryant, 2007). The critical issue of whether dog disturbance is a conservation issue for birds remains virtually undocumented, partly because studies are complex and require substantial quantities of data.

4.4.2 Mammals

Like birds, there is a lack of empirical work on the broader impacts of dog disturbance on wild mammals. The scant evidence available implies broad and potentially significant effects: (1) in areas where dogs on leashes are common; (2) where feral or free-ranging dogs are abundant; and (3) for small mammals. In addition to the potential effects on group sizes discussed in Section 4.3.2 above, free-ranging dogs also have a direct negative influence on the kid:female ratio of mountain gazelles (Manor and Saltz, 2004), suggesting the potential for significant impact on population growth and viability (Gaillard et al., 1998). When some of the dogs were removed from a particularly abundant population near a garbage dump, the kid:female ratio increased significantly. Gingold et al. (2009) found similar results for mountain gazelle responses to guard dogs, where increased vigilance and time spent running came at the expense of time resting and walking, which led to decreased numbers of fawns per female. The burrows of small mammals may become damaged by dogs (Sime, 1999), and even dogs walking over top of burrows may cause a disturbance (Mainini et al., 1993). Finally, Gerrodette and Gilmartin (1990) attribute the recovery of Hawaiian monk seals at Kure Atoll, after the species was listed as endangered in 1976, to US Coast Guard efforts aimed at reducing disturbance by dogs and automobiles.

Free-ranging dogs can act as predators of a variety of mammals (Ritchie et al., Chapter 2), and this may have significant population- and community-level effects. These effects, however, may be most relevant for feral or free-ranging dogs as there is little evidence that leashed or controlled dogs in recreational

areas have any effect on species richness or abundance. Forrest and St. Clair (2006) found minimal effects of off-leash dogs on the diversity and abundance of small mammals (and birds) in urban parks. While native carnivore species richness was lower in public areas where dogs were permitted, compared to non-public protected sites (especially for coyotes and bobcats), overall carnivore species richness and abundance was unaffected (Reed and Merenlender, 2011). Therefore, while controlled dogs may influence the activity and movement patterns of wild mammals, there is currently little evidence to suggest they have broad community-level effects.

4.4.3 Other vertebrates

Virtually nothing is known about the impacts of disturbance by dogs on other vertebrates. However, Section 4.3.4 clearly documents a range of responses to dogs, which are likely to have consequences at least at the individual level. While not specific to dogs, human disturbance can decrease the habitat occupancy of amphibians (Rodríguez-Prieto and Fernández-Juricic, 2005).

4.5 Managing dog disturbance

The high usage of natural areas by dog walkers, their high numbers and mobility, and their high potential to cause disturbance means that in some areas they may represent a high management priority for mitigating disturbance to wildlife (Le Corre et al., 2009; Underhill-Day and Liley, 2007). This section focuses on owned dogs. Managing disturbance by dogs will involve either constraining their occurrence, or altering the way they are perceived by wildlife by reducing threatening aspects of dog behavior or by mitigating the deleterious effects of wildlife responses.

4.5.1 Constraining the occurrence of dogs

'Off limit' areas, or restrictions on seasons or periods of the day when dogs are permitted, are commonplace (e.g., banning dogs from islands with monk seal colonies; Gilmartin, 1983), but available data indicate that compliance is rather low (see Box 4.2). Variants of spatial restrictions include buffers (separation distances between natural values and

incompatible uses) but recreationists, including dog walkers, are allowed in some 'buffers' (Weston et al., 2009). In particular, natural parks and reserves in many parts of the world prohibit owned dogs, though exceptions occur in some coastal parks (e.g., in Australia). Such restrictions can work (Lafferty et al., 2006). Key to the success of restriction is achieving adequate compliance, which can be promoted through the provision of 'dog-areas' that allow off-leash exercise for dogs and educational initiatives (Williams et al., 2009).

4.5.2 Altering the stimulus

Leashing reduces the speed, degree of roaming, and chasing by dogs and generally decreases response rates and distances among wildlife (Bloor, 2005; Hudson, 1982; Lafferty, 2001b; Weston and Elgar, 2007). For example, unleashed dogs disturbed seven times more red grouse (*Lagopus lagopus*) than leashed dogs (Hudson, 1982). Leashing not only alters problematic aspects of dog behavior, but could also underpin habituation on the part of the wildlife. On one Californian beach, once a protection area for birds became established, leashed dogs no longer caused any bird disturbance, while all disturbance in the protected area from dogs was from unleashed dogs (Lafferty et al., 2006). However, leashing does not prevent barking or other potentially disturbing cues (Randler, 2006).

The designation of leashing laws has not proven to be a major barrier to effective coexistence between dog walking and wildlife, and in many countries 'leash-only' zonation is common in public lands. Rather, the main barrier appears to be the low compliance rates with these regulations (see Box 4.2). Low compliance with leashing laws may explain the failure of some 'gradient' studies to correlate avian or mammal species diversity with prevailing dog regulations (Forrest and St. Clair, 2006). The requirement for human social change with respect to complying with leash laws is undeniable, though better information and signage is often required to more clearly demarcate different dog zones. Managers may be reluctant to tackle the unpopular and apparently insurmountable problem of low compliance with leashing laws, but over the medium to long term, compliance may be improved. Even where compliance with leashing regulations is low,

sustained efforts by managers can increase leashing rates (Dowling and Weston, 1999). The presence of a strong social norm among dog walkers suggests that if leashing becomes frequent enough, and therefore expected, many dog owners would leash their dogs on beaches (Williams et al., 2009). Many codes of conduct are available, such as advice to take particular care with dogs around seals or beach-nesting birds (e.g., New Zealand Department of Conservation, 2007).

4.5.3 Mitigating deleterious responses

Responses potentially compromise energy balances, reduce survival, or compromise parental care. Theoretically, if responses cannot be prevented, then management that mitigates the processes that lead to deleterious effects can reduce the impact of disturbance. Examples may include the use of nest cages or shelters for flightless young, which provide thermal insulation and protection of unattended young from predators including dogs (Maguire et al., 2011b).

4.6 Research needs

Compared with other sources of disturbance to wildlife, such as walkers and aircraft, relatively few studies consider disturbance by dogs (e.g., only 2.4% of 211 articles on disturbance to waterfowl mention dogs; Dahlgren and Korschgen, 1992). This chapter has demonstrated a series of critical information gaps regarding disturbance of wildlife by dogs.

First, in terms of dogs as a stimulus, there is a poor understanding of dog occurrence in space and time, in relation to the occurrence of wildlife. An important aspect of space use by dogs is their roaming in natural habitats. How far owned dogs stray from their owners and which types of habitat are penetrated and to what extent, represent research questions that, if addressed, would map the extent of any problem and offer management solutions. While relatively inexpensive, commercially available GPS loggers exist for dogs, these do not appear to have been used to study dog movements. Virtually nothing is known about disturbance by un-owned dogs or unmonitored owned dogs. Additionally, few studies have attempted to separate the visual, auditory, and olfactory cues associated

with dogs, and the extent to which these disturb wildlife. Barking, in particular, may be detectable at greater distances than sight or smell of dogs and therefore warrants investigation.

Second, two aspects of wildlife response to stimuli represent research priorities:

1. With few exceptions, only behavioral studies of the response of wildlife to dogs are available, so physiological responses remain largely unknown (but see, for example, Berger et al., 2007; MacArthur et al., 1982). The available evidence suggests they may occur in the absence of behavioral responses, and so be subtle and underestimated. Additionally, physiological responses may occur at greater distances than behavioral responses (i.e., may be precursors to behavioral responses) and so may occur more frequently. They may also be costly, at the individual level manifesting potentially themselves as poorer condition or lower 'health' (e.g., disease resistance), and at the population level potentially manifesting themselves as lower average survival or longevity.
2. The consequences of responses for individuals have rarely been investigated, in general or specifically for dogs, yet these will underpin population responses to disturbance. Scaling up, perhaps the most critical information gap is the link between wildlife population viability and disturbance by dogs, in particular the specific role of dogs in systems where dog disturbance is one of a variety of forms of disturbance. Tolerable disturbance thresholds for populations, if they exist, remain unknown. The influence of disturbance on population viability is likely to be highly context-specific, for both sites and species. Beyond populations, further investigation of the evolutionary costs and benefits of disturbance responses in relation to predator environments might aid predator and species management programs.

Finally, very few instances exist of successful management of disturbance by dogs (possibly some remain undocumented), and this hampers management. A critical element of this will involve social research. The lack of uptake of adaptive dog-wildlife management is regrettable, because this

could engage behavioral ecologists with managers to tackle, and hopefully help resolve, the controversial issue of dogs as agents of disturbance.

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