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Bark in the Park: A Review of Domestic Dogs in Parks

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Abstract The presence of domestic dogs *Canis familiaris* in public open spaces is increasingly controversial. In our review of the literature, we located 133 publications of various types (papers, reports etc.) that examine some aspect of dogs in parks and open spaces (50 % focussed solely on dogs). There has been an exponential growth in the cumulative number of articles ($R^2 = 0.96$; 82 % published since 1997); almost all pertain to temperate latitudes (97 %) and most to the northern hemisphere (62 %). Most articles focus on impacts on wildlife (51 %), zoonotic diseases (17 %), and people's perceptions regarding dogs (12 %). Articles mostly describe problems associated with dogs, while reports of low compliance with dog regulations are common. We outline six major findings regarding dogs in parks: (1) there is a paucity of information on dogs in parks, particularly in relation to their interactions with wildlife and regarding their management; (2) published studies are mainly restricted to a handful of locations in developed countries; (3) sectors of societies hold different views over the desirability of dogs in parks; (4) the benefits and risks of dogs to humans and park values are poorly documented and known; (5) dogs represent a notable

disease risk in some but not all countries; and (6) coastal parks are over-represented in the literature in terms of potential negative impacts. Park managers globally require better information to achieve conservation outcomes from dog management in parks.

Keywords *Canis familiaris* · Compliance · Leashing · Bibliometric · Reserves · Open space · Perceptions · Wildlife · Conservation

Introduction

Domestic dogs *Canis familiaris* originated from the domestication of wolves (*C. lupus*) in East Asia around 15,000 years ago (Savolainen et al. 2002). Dogs are highly adaptable, social carnivores that are the most widespread and abundant canids, occurring in most places where there are human populations (Green and Gipson 1994; Silva-Rodríguez and Sieving 2012). Such is their ubiquity and abundance that domestic dogs (henceforth “dogs”) occur in a variety of contexts which can be classified in terms of their relationship with, and degree of management by, humans. No clear classification of the behavior and ecology of *C. familiaris* is currently available, so it is necessary to offer one here for clarity (Table 1).

Domestic dogs can be kept for companionship and/or working roles (e.g., police dogs, therapy/service dogs, livestock/wildlife guardian dogs, hunting dogs). Approximately 20–30 % of households globally have a companion dog (Ioja et al. 2011). While the home range of fully domesticated dogs is usually restricted to the properties of their owners, those of free-ranging domestic dogs usually extend beyond the dwellings and properties in which their owners reside, perhaps especially in the developing world.

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These departures from property boundaries may be unsupervised (perhaps especially common in the developing world) or supervised. Thus, dogs often go beyond property or village boundaries, usually with humans, and often into public open spaces such as parks and reserves, henceforth “parks” (Reed and Merenlender 2008). Indeed, parks are often designated to support dog exercise, while other pets are not afforded such consideration. In much of the developed world, dog walking is a key motivation for dog owners visiting a park (Sterl et al. 2008). While dog owners often perceive dog walking as having significantly less impact on natural areas than other users (such as horse riders, motor boat users, etc.; Sterl et al. 2008), some park managers consider dogs to be a major management challenge (Le Corre et al. 2009). In many areas, the management of dogs in natural areas or open space is controversial (Walsh 2011), with debate over the relative positive and negative influences of dogs on their surroundings (Johnston et al. 2013).

Currently, there is a relatively limited understanding of the ecology of human-associated dogs or their interactions with humans, flora, and fauna within natural areas or open spaces (Lenth et al. 2008). Here, we present a systematic review of the available literature, to synthesize what is known about this issue, and identify information gaps. We focus on fully domesticated and free-roaming dogs (Table 1), because these are often more directly under the influence of humans and so able to be managed more directly than feral dogs.

Methods

We used “bibliometric content analysis” (BCA), a process of classifying (and simplifying) substantial amounts of complex information to produce more manageable data that can be used to identify patterns and trends and make inferences from them (Weber 1990; Yarwood et al. 2013). Coding was performed by a small group of researchers (KE, TS, and Amy Shaw [Deakin University]) who, in conjunction with the other authors of this paper, developed and applied standard codes. There were seven key codes which classified publications into author type; article type; key focus of publication; level of compliance with dog regulations (if applicable); the impact focus of dogs (positive, negative or neutral); area/scale of publication; and the level of focus publications had on dogs. These seven key codes were further sub-categorized for detailed analysis.

The literature was located by using a variety of search techniques. The main searching was conducted using online search engines Google and Google Scholar, as well as abstract and citation databases Web of Knowledge and

Table 1 A conceptual classification of *Canis familiaris* in relation to their association with humans

Term	Definition	Source
Fully domesticated dogs (e.g., pets and working dogs)*	Dogs which are solely reliant upon humans, companion animals, are restricted to owner’s boundaries and reliant upon owner’s for all basic needs	Holderness-Roddam (2011)
Free-roaming dogs (e.g., village dogs)*	Dogs that are owned, however, are not restricted to boundaries, are free to wander, and do not solely rely upon supplemental feeding, however, rarely consume prey if hunting	Meek (1999)
Feral dogs	Dogs that have been “abandoned” or have escaped, no longer dependent upon humans, hunt for food, often form packs, are starting to become aggressive toward humans and consume their prey	Green and Gipson (1994)
Wild dogs	Feral dogs after a number of consecutive breeding seasons, which have become wild animals, form packs, hunt, kill, and consume their prey and are often or can be aggressive toward humans	Green and Gipson (1994)

Although the common name of the species is “domestic dog,” not all individuals of this species are domesticated

* Dogs focussed on in this review

Scopus, and Informit (<http://www.informit.com.au/>). We used combinations of the keywords “dogs,” “dog-walking,” “companion animals,” “canines,” “pets,” “parks,” “coastal,” “beaches,” “management,” “behaviour,” “protected areas,” “policy,” “leash,” “impact,” and “environmental impact.” The literature in the health and agricultural sciences was not reviewed comprehensively but may have been located through keyword searches. Other minor sources were checked, and any potential articles discovered in reference lists or as part of other literature searches involving dogs (e.g., Gompper 2014) were included. We acknowledge that not all literature will have been uncovered, particularly that which appear in regional or local outlets, with limited distribution, and that not digitized or available online.

We complemented the BCA by incorporating qualitative aspects of our literature review, citing relevant sections of publications as appropriate. Our aim was to derive general findings which might inform future research. The resolution offered by the literature for any one category (e.g.,

Fig. 1 Countries in which articles on dogs in parks were located by the present study (Dark gray shading indicates countries where dog studies were located)

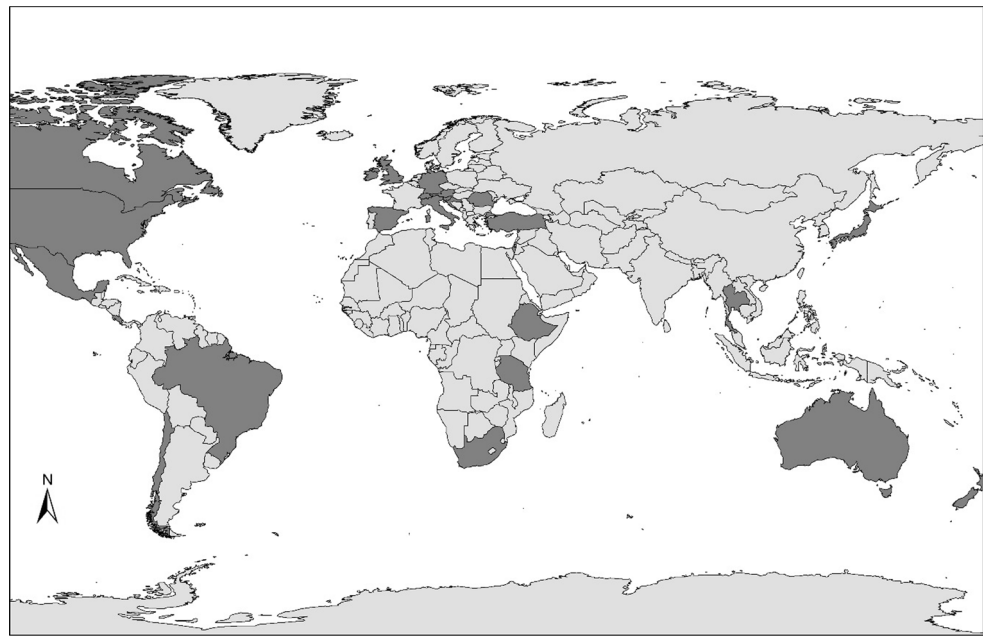
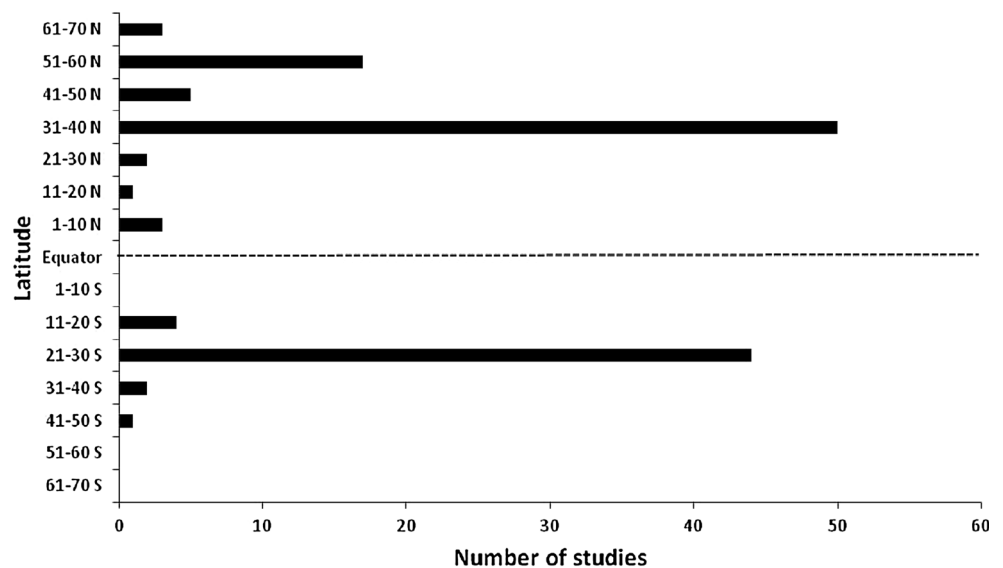


Fig. 2 The distribution of articles across latitudes (taken from centroid of country) (n = 133)



“coastal parks”) was that which was available across a reasonable number of articles, so as to permit generalizable findings. While it might have been desirable to separate such categories into finer scale components (e.g., beaches vs non-beaches, heavily used vs less-used parks), these details were rarely, if ever, available.

Results

Overall, 133 relevant publications were located (74.8 % from online searches, the remainder from citations of those articles or incidental discoveries). These consisted of

research papers or reports (75.2 %), management plans (9.0 %), review articles (6.8 %), newsletters (6.0 %), and book chapters and theses (3.0 %) (see Supplementary Material for the full list of publications).

Publications between 1973 and 2012 were reviewed and found to document dog interactions in parks in 29 countries. The literature was dominated by contributions from the northern hemisphere (62.4 %), in comparison to southern (34.6 %) and equatorial (3.0 %) regions (North America, 33.8 %; Australasia, 30.8 %; Europe, 20.3 %; Africa, Asia, the Middle East, 15.0 %) (Figs. 1, 2). Most publications had authors affiliated with universities (67.4 %), government (from local to national; 12.0 %) including parks services

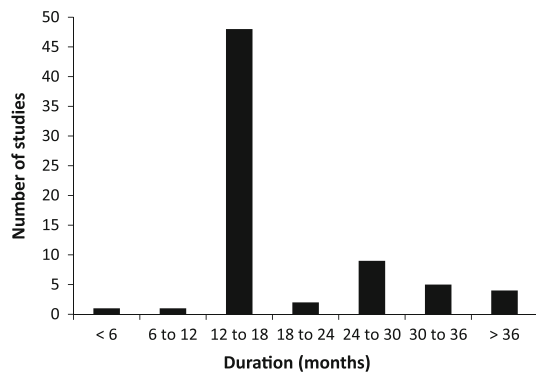


Fig. 3 The duration (in months) of data collection in surveyed research articles ($n = 70$)

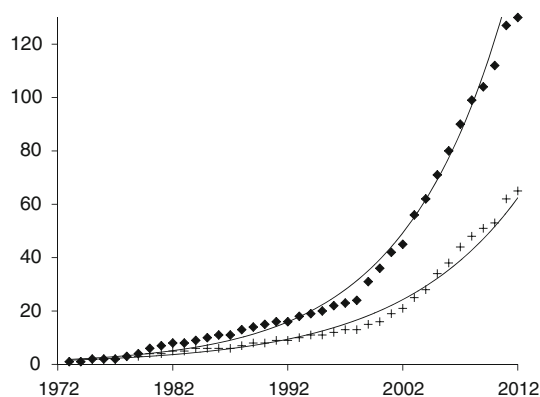


Fig. 4 The number of publications involving or focusing on dogs in parks over time. Exponential curves are fitted, *black diamonds* represent all articles uncovered which mention dogs, *crosses* represent articles which focus exclusively on dogs

(10.5 %), with fewer from sources such as non-government organizations and consultants. The modal period of data collection reported by (relevant) publications was 12 months (Fig. 3).

There has been an exponential growth in the number of publications on dogs (all papers, R^2 [from the exponential fits shown in Fig. 4] = 0.96; those that focus only on dogs [50.0 % of articles], $R^2 = 0.97$; three articles had no date). Most (82 %) were published between 1997 and 2012 (Fig. 4). In the southern hemisphere, all but three (91.3 %) were published between 1999 and 2012.

Dogs frequently accompany humans into parks and reserves, and are often the most common carnivore in those areas (Butler et al. 2004). The spatial occurrence of domestic dogs in developed countries is strongly associated with the distribution of humans (Silva-Rodríguez and Sieving 2012). Of 129 relevant articles, 25.6 % involved coastal areas, 54.7 % non-coastal, and 17.1 % involved both. This appears to be biased toward coasts, given that they occupy smaller

areas than terrestrial parks but also possibly reflect human habitation with nearly 40 % of the global population living within 100 km of the coast (Agardy and Alder 2005). In terms of tenure (123 articles), 43.9 % involved sites which had no restrictions on public access (e.g., public parks and open space), 38.2 % involved areas that were protected for wildlife and allowed regulated public access (e.g., national parks), and 17.8 % involved areas that were prohibited for the public and protected for wildlife (e.g., strict nature reserves). There was no difference in the frequency at which publications focussed on areas on or away from the coast (contingency analysis, $\chi^2 = 0.21$, $df = 1$, $P = 0.645$). Articles ($n = 121$) ranged in scale from site/place (40.5 %), to local landscape (16.5 %), regional (29.8 %), national (8.3 %), and international or global (5.0 %).

Topics covered

The publications reviewed focussed on two key themes: “the effects of dogs on wildlife” (wildlife defined as free-living fauna; 51.1 % of articles) and the “health risks that dogs pose,” to both wildlife and humans (16.5 %). Before 1996, all papers published on dogs were on these two topics. After 1996, the topic of “human dimensions of dogs” (12.0 %) began to feature in publications, coinciding with the growth of this field in wildlife management (Miller 2009). One theme which is of critical importance to this review is the management of dogs, so this is also considered below.

Effects on wildlife

Sixty-seven publications examined the impact of dogs on wildlife in parks and open space; however, the extent to which dogs were the focus of the research varied. These studies focussed on birds (68.6 %; $n = 46$), especially shorebirds (56.5 % of bird studies), and mammals (31.3 %). The impact of dogs on reptiles, amphibians, fish, and invertebrates appears virtually unstudied, and no publications we uncovered documented impacts on flora. Thus, there is a strong taxonomic bias in studies of the impact of dogs on biodiversity. Some 62.7 % of these publications reported experimental data, and 16.4 % were observational; 8.3 % employed interviews or questionnaires of dog owners or the general public.

Three mechanisms through which dogs could detrimentally affect wildlife were described: (1) direct mortality of wildlife through the predatory action of dogs (28.3 % of publications), (2) disturbance (the disruption of normal behavior due to the presence of dogs) (62.7 % of publications), and (3) disease transmission to wildlife (9.0 % of publications). The publications focussed exclusively on

terrestrial wildlife, though dogs conceivably influence aquatic organisms by predation, pollution, and physically increasing turbidity.

Of the studies examining the effect of dogs (to some degree) on wildlife ($n = 67$), 19 have investigated the effects of dogs *preying on wildlife*. Thirteen of these studies report observing either direct predation or strong evidence of predation by dogs, whereas the other six studies mention predation as the end result due to excessive disturbance caused by dogs. Overwhelmingly, these studies report chasing and killing of prey by dogs, but none report eventual consumption of prey. Direct mortality is reported infrequently in the literature, but sometimes may be substantial; in addition to ground-dwelling mammals and flying birds, at least one flightless bird (southern cassowary *Casuarius casuarius johnsonii*) and one arboreal mammal that climbs to the ground to move between trees (koala *Phascolarctos cinereus*), suffered dog-related losses significant enough to constitute a conservation problem (Kofron and Chapman 2006; Lunney et al. 2007). Prey include not only adult wildlife but also young and eggs (Leseberg et al. 2000).

Of the studies looking at the effect of dogs (to some degree) on wildlife ($n = 67$), 46 have investigated the effects of dogs *disturbing wildlife*. Disturbance by dogs is an indirect mechanism affecting wildlife; however, as for most other research on disturbance to wildlife, no direct linkages between dog disturbance and individual or population fitness have been established (see Hockin et al. 1992). One special case where disturbance may be beneficial, namely where guard dogs disturb predators, thereby protecting a species of conservation significance, was not described by any article uncovered in our search. Dogs detrimentally affect some threatened species through lethal and sublethal mechanisms (Silva-Rodríguez and Sieving 2012), with threatened species generally more prone to population decline. Studies presenting results on how wildlife reacts to dogs report that flushing behavior of mammals and birds is usually greater when pedestrians are accompanied by a dog compared to pedestrians walking alone (MacArthur et al. 1979, 1982; Yalden and Yalden 1990; Mainini et al. 1993; Lord et al. 2001). However, this impact can be species specific with some species less sensitive to disturbance by dogs, e.g., American robins *Turdus migratorius* (Miller et al. 2001; Marcum 2005). The notion that dogs are traditional predators of many wildlife species, and indeed still behave like predators (e.g., chasing), is a common theme in the literature.

The literature demonstrates that the key factor that influences whether domestic dogs impact upon wildlife in developed countries is whether dogs are allowed to roam free (which is influenced by their owners) and the extent to

which they do so (influenced by individual dogs) (Weston and Stankowich 2014).

Health risks

Nineteen studies examined the disease transmission potential of dogs to humans in public open space. Several studies have looked at the role public open space plays in the transmission of *Toxocara canis* (dog roundworm), a nematode that can infect humans, and a vector for a number of diseases (e.g., ocular toxocariasis and/or visceral larva migrans). These studies analyzed prevalence of eggs in samples of substrate (sand or soil) in public open space and report rates of occurrence from very low up to 45 % of samples containing eggs. Authors variously conclude the risk of infection to humans varied from minimal to substantial, depending on the location and context.

Dogs have also been identified as the key component to the spread of rabies and canine distemper to humans and wildlife in some countries (Macdonald 1980; Fekadu 1982; Acosta-Jamett et al. 2011; Davlin and VonVille 2012). The potential for zoonotic diseases to infect wildlife presumably depends, at least partly, on the taxonomic similarity between native faunas and dogs and the degree of overlap between dogs and those faunas.

Human dimensions

Twelve percent of the articles concentrated on human perceptions regarding dogs in parks, focusing on what people value about parks and open spaces (e.g., “Is dog walking a high priority?”), views on the management of dogs in parks (e.g., “Do visitors want dogs banned or on leash only?”), perceptions of one’s own dog and its impact on the environment, and how people respond to various management strategies (e.g., “Does education change awareness?”, “Do people comply with regulations?”) (see also Miller et al. 2014).

People’s perceptions of dogs vary globally and locally. The place of dogs in urban parks is a controversial issue worldwide; many dog owners desire less restrictions and greater access (Slater et al. 2008; Kubinyi et al. 2009), while many non-dog owners seek greater regulations and restrictions on dog access and activity (Instone and Mee 2011). Australia, Brazil, and the United Kingdom (UK) are the largest source of publications focusing on people’s perceptions of dogs (11.8 % of all articles surveyed), a majority of which were focussed solely on coastal habitats.

Sterl et al. (2008) found that only 40 % of park visitors in their study of visitor awareness in the Donau-Auen National Park in Austria were aware that wildlife can be disturbed by dogs. In Australia, Williams et al. (2009)

found that while most dog owners (96 %) surveyed on Victorian beaches were aware of dog control laws, only 18 % of dog owners were aware of the lasting negative impact that dogs can have on beach-nesting birds.

Pereira et al. (2003) found that 95 % of people wanted dogs banned from Brazilian beaches; substantial support for dog bans has been reported from other studies in other parts of the world (e.g., Morgan 1999; Nelson et al. 2000); although in other studies people support dogs in parks, for example, Semken et al. (2011) found 92 % of dog walkers, and 54 % of other users would like the Balcombe Estuary Reserve in Victoria, Australia to remain open for dog walking. In a study examining park visitor perceptions in Bucharest, Romania, 15.9 % of visitors considered dogs to be the main “problem” in urban parks (Ioja et al. 2011). Reasons cited as to why dogs should be banned from beaches in the UK, included nuisance, safety, and litter concerns (Morgan 1999).

Multiple-use parks often seek a balance between the benefits and costs associated with different or competing recreational activities. Publications ($n = 110$) were categorized as to whether dogs were considered to provide benefits or threats/nuisance to humans and wildlife. The articles we located were heavily biased toward examining threats or nuisance caused by dogs (overall, 90.9 %, $n = 100$, $\chi^2 = 73.64$, $df = 1$, $P < 0.001$). We acknowledge that articles dealing with human and psychological health benefits of dogs may have gone undetected by our literature search and that such articles will generally not deal specifically with parks. As the human health benefits of using parks and open space are actively promoted by some parks agencies (e.g., Parks Victoria 2006), it is likely that health and psychological benefits are accruing to people walking their dogs in parks. Nonetheless, the magnitude of benefits or risks posed by dogs to the natural and other values of parks remains largely unknown.

Management of dogs

A variety of management options aimed at avoidance of negative interactions between dogs, people, and wildlife were evident from the literature, including temporal and spatial restrictions of dogs, leashing regulations, and codes of conduct.

Many of the publications we examined focussed on visitor compliance with dog regulations. Overall, 72.2 % of publications mentioned prevailing dog regulations, usually referring to more than one regulation (1.5 ± 0.7 regulations per article; 1–3). Of the 96 publications that mentioned regulations, 46.3 % involved “on leash” areas, 29.4 % “off leash,” and 23.5 % to areas where dogs were not allowed. Compliance was categorized as “high” (researchers observed greater compliance than non-compliance by dog owners), “moderate” (observed both non-compliance and

compliance to roughly an equal extent), or “low” (observed more non-compliance than compliance). Of six studies describing areas where dogs were not allowed, one reported high compliance, and five reported low compliance. Twenty-two studies involved “on leash” areas as the only regulations; most (63.3 %) reported low compliance, and 36.4 % reported medium compliance. No study reported high compliance. Thus, studies reported low compliance more frequently than expected ($\chi^2 = 13.45$, $df = 2$, $P = 0.001$). Publications reporting low compliance with leashing regulations were from the USA, UK, Japan, Canada, Australia, and Austria (i.e., developed world countries mostly from the northern hemisphere). Those reporting moderate compliance were from Australia, New Zealand, England (UK), Germany, Ireland, Spain, Wales (UK), and USA. We found no articles documenting the relative efforts of compliance officers in enforcing regulations, though it might be predicted that effectiveness of enforcement may be positively associated with enhanced compliance (after Dowling and Weston 1999). Social expectations around leashing may mean that compliance improves as more people leash their dogs (Williams et al. 2009).

Nine articles discussed the benefits and drawbacks of “dog parks” – public spaces that allow dogs to be off-leash. Dog parks are a common dog management strategy that can potentially restrict the spatial extent of any deleterious effects of dogs (Instone and Mee 2011). However, such off-leash areas can be controversial. While one section of the community desires dogs to have unconditional access to parks, another seeks to limit and control access (McCormack et al. 2011).

Very few studies investigated benefits of dog management, either in terms of increasing leashing rates or reducing dog occurrences in areas where they should not occur (i.e., proximate measures) (but see Dowling and Weston 1999) or in terms of improving natural values such as biodiversity (Forrest and St Clair 2006). Leashing restrictions are one key form of management, and indications are that they would effectively reduce disturbance to wildlife (e.g., Weston and Elgar 2005), although they are associated with poor compliance (usually < 10 %; Weston and Stankowich 2014) and do not prevent dog barking which can also disturb wildlife (Randler 2006).

Very few articles document management efforts, or potential solutions to the problem of low compliance, though this is of key interest to managers.

Discussion

Based on this review, we offer six general findings, derived from our bibliometric and qualitative approaches, of the existing literature regarding dogs in parks.

- (1) There is a paucity of information on dogs in parks, particularly regarding their interactions with wildlife and their management. We confirm two assertions by previous researchers, firstly that there are relatively few comprehensive studies investigating the effects of domestic dogs have on the natural environment (Wandeler et al. 1993; Brickner 2002; Manor and Saltz 2004), and secondly, that research into the effectiveness of different dog management approaches in protecting natural values is lacking (Reed and Merenlender 2011). The dearth of information is surprising given the prevalence of dogs in many societies and the controversy that can be associated with the occurrence of dogs in public open space. However, given the exponential growth in studies we report, we forecast an improved information base for managers of open public space with respect to dogs.
- (2) Research effort to date has been biased. Most available information on dogs in parks comes from the developed world, in particular North America and Europe, where certain cultural integration of dogs occurs (e.g., “ownership” by individuals rather than village communities) and where dogs are generally well managed and cared for. We know little about dogs in parks in the developing world despite the high abundance and widespread distribution of dogs, and it is likely that dogs and their owners behave differently compared with those in the developed world. In both these regions, canids are part of native fauna in the wild (or at least were in the past), and other species of wildlife have evolved in their presence. The situation is quite different in Australia and New Zealand, for example, where only in recent evolutionary times (in the case of dingos *Canis lupus dingo* in Australia) have any canids been present in the ecosystem.
- (3) Societies debate the desirability of dogs in parks, with some sectors actively objecting to their presence, others keenly advocating for more access. Despite the high profile of the issue among the public, there is a dearth of publications in the peer-reviewed literature on what is driving management decisions in relation to dog management in parks. In many countries (especially in Europe), management decisions are being driven by public health concerns related to dog feces (Lowe et al. 2014), and human safety is also likely to feature as a driver of management decisions (authors, pers. obs.).
- (4) The benefits and risks of dogs to park values are poorly documented. For example, dogs may suppress or exclude introduced pest species (e.g., red foxes *Vulpes vulpes* or domestic cats *Felis silvestris catus* in Australian parks; see Vanak and Gompper 2010), or, in areas where dogs are common, regulate, or limit the populations of native species which would otherwise be more abundant (e.g., herbivores). The actual impact of dogs on wildlife or flora is difficult to demonstrate, and no study clearly links population viability of wildlife or flora with disturbance or mortality associated with dogs. However, numerous studies indicate negative effects on individual native animals, some of which influence parameters (e.g., reproductive success) that are likely to influence population viability. Some dogs in parks behave as predators, harassing, or killing wildlife, including large species (e.g., black swans *Cygnus atratus*; Prezel 2009). Dogs are also likely to influence the occurrence and behavior of other domesticated animals, such as cats, which themselves are thought to be predators of wildlife (Baker et al. 2005).
- (5) Dogs represent a notable infectious disease risk in some but not all countries yet apparently aid in the prevention of some chronic human diseases through promoting exercise and mental wellbeing. The infectious disease risk to humans and wildlife from dogs appears to occur in particular areas (e.g., Turkey) and to be unproblematic in others (e.g., Australia). While some diseases for which dogs are a vector are geographically limited (e.g., rabies), others are not, yet the health issues posed by dogs to humans, as reflected in our literature search, varied between countries perhaps because of prevailing mediating factors such as accessibility of veterinary care. In some countries, widespread compliance with removal of feces (a vector of some diseases) by dog owners is evident and has occurred over the last few decades (Lowe et al. 2014).
- (6) Coastal parks are over-represented in the literature in terms of potential negative impacts (here, these include beaches, which are the site of much dog activity; Williams et al. 2009). Coasts apparently experience a relatively high degree of usage by dogs (adjusting for area, a great proportion of studies occur for dogs on coasts), and dog regulations in protected areas on coasts are often relaxed in comparison with terrestrial protected areas. For example, while many terrestrial protected areas do not permit dogs, dogs are permitted in some equivalent coastal parks (e.g., in Victoria, Australia). We acknowledge that seasonal and temporal dog restrictions occur on some beaches.

Key information gaps and future research

Given the dearth of available information on dogs in parks, many information gaps exist, and opportunities for future

research are numerous. Here, we identify a set of key information gaps and research opportunities, from the perspective of improving dog management in parks.

- (1) Many aspects of interest with respect to dogs are likely to vary with the prevailing nature of dog–human relationships, and legislative and enforcement regimes. This includes the issue of whether different types of parks are associated with differences in dog occurrence, behavior, or impact. Characterizing and mapping human-canine relationships and relevant laws and their effectiveness by country (or province) would be a fruitful endeavor but were beyond the scope of the current study (few studies explicitly outlined prevailing laws or regulations, and these are often temporally labile). Several countries (e.g., UK) have national legislation related to dogs, but often local authorities apply a range of specific measures at a fine scale to implement dog management.
- (2) The abundance and distribution of dogs in parks is poorly known.
 - (a) Little is known about the seasonality, frequency of occurrence, abundance, and behavior of dogs in parks (indeed, this also applies to their owners and other recreationists). Presumably, in the developed world, most dogs are present in parks during daylight hours, in settled weather, and in line with human social factors, such as holidays and work hours (see, for example, Maguire et al. 2011), but this remains to be demonstrated.
 - (b) The movements of dogs, and the extent of their space use, within parks are currently unknown. Dogs may be confined to small parts of parks, or not roam far. This lack of information is surprising given the ease with which dogs can be studied. Tracking studies of dogs in open public space are needed to inform the degree of exposure of parks to dogs and to aid in the planning of park usage.
- (3) Quantifying the impacts of dogs on parks. Throughout much of the developed world, people and their dogs co-occur in space and time so closely that it has been suggested that they should be managed as a cooperative social unit (Bekoff and Meaney 1997). Additionally, although parks are usually multiple-use areas, in at least some areas, perhaps where dog densities are high, or dog management is poor, it might be that dogs effectively exclude other users. Alternatively, dog walking areas may attract those who own or enjoy the company of dogs. This highly

testable idea (potentially adopting diversity indices from community ecology to quantify recreational diversity) could inform management authorities about equitable access to multi-use parks and the relative impacts of different user groups on parks. Humans without dogs can also have deleterious effects on the natural values of open public space and disturb wildlife (Weston and Elgar 2007). Thus, experimental designs which compare parks with people and dogs, those with people alone, and perhaps a reference category of parks without people or dogs, could help unravel any deleterious impacts which can be attributed specifically to dogs.

- (4) Very little is known about the effectiveness of dog management in parks, and the available evidence suggests some approaches are associated with either little enforcement or compliance or both. Because the jurisdictions responsible for managing pets are generally local in nature (if they are present), centralized databases of dog management activities are apparently unavailable. This prevents study of the relationship between enforcement and effectiveness of regulations. Critical to effective management will be an enhanced understanding of the values, attitudes and beliefs of dog owners and non-dog owners, and the factors which reinforce or might alter existing behaviors.

Conclusion

Dogs in parks are likely to remain a controversial issue in many countries, and further research is required to better inform park management decisions in regard to dogs. Our understanding of the benefits and costs to parks, people, and wildlife posed by dogs needs to be informed by a better understanding of dog activity in parks and the actions of their owners, where they have owners. Dramatic changes in the behavior of dog owners in some countries (e.g., the collection of feces for disposal), and the influence of social norms on aspects of dog walking (Williams et al. 2009), mean that it is possible to change the way societies manage their dogs. Thus, we suggest that, should impacts of dogs on natural or other values prove to be deleterious and substantial, and consequent management objectives are set, societies can aspire to improved dog management in public open space.

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