Wildlife responses to pedestrians and dogs

Scott G. Miller, Richard L. Knight, and Clinton K. Miller

Abstract As participation in outdoor recreational activities escalates, land managers struggle to develop management policies that ensure coexistence of wildlife and recreation. However, this requires an understanding of how wildlife responds to various forms of recreational activities and the spatial context in which the activities occur. Therefore, we measured responses of 2 species of grassland songbirds, one species of forest songbird, and mule deer (*Odocoileus hemionus*) exposed to a pedestrian, a pedestrian accompanied by a dog on leash, and a dog alone (only for grassland birds), on and away from recreational trails. We assessed the "area of influence" for each treatment by determining the probability that an animal would flush or become alert (for mule deer only) given its perpendicular distance to a trail or a line of movement in areas without trails. When animals were disturbed, we measured flush distance (the distance between the disturbance and the animal when flushed), distance moved, and, for mule deer, alert distance (the distance between the disturbance and the deer when it became alert). For all species, area of influence, flush distance, distance moved, and alert distance (for mule deer) was greater when activities occurred off-trail versus on-trail. Generally, among on-trail and off-trail treatments in grasslands for vesper sparrows (*Pooecetes gramineus*) and western meadowlarks (*Sturnella neglecta*), the smallest area of influence and shortest flush distance and distance moved resulted from the dog-alone treatment, and these responses were greater for the pedestrian-alone and dog-on-leash treatments. In forests, for American robins (*Turdus migratorius*), the area of influence, flush distance, and distance moved did not generally differ between the pedestrian-alone and dog-on-leash treatments. For mule deer, presence of a dog resulted in a greater area of influence, alert and flush distance, and distance moved than when a pedestrian was alone. Natural lands managers can implement spatial and behavioral restrictions in visitor management to reduce disturbance by recreational activities on wildlife. Restrictions on types of activities allowed in some areas such as prohibiting dogs or restricting use to trails will aid in minimizing disturbance. Additionally, managers can restrict the number and spatial arrangement of trails so that sensitive areas or habitats are avoided.

Key words American robin, disturbance, dog, mule deer, outdoor recreation, pedestrian, trail, vesper sparrow, western meadowlark

As participation in outdoor recreational activities escalates, land managers are becoming concerned about the effects of recreation on wildlife (Boyle and Samson 1985, Knight and Gutzwiller 1995). Because outdoor recreation has become common and widespread, managers must now incorporate actions into their management decisions that minimize potential impacts of these activities. This

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requires an understanding of how wildlife responds to various forms of outdoor recreation and also the temporal and spatial context in which the activity occurs (Knight and Cole 1995).

Information on how wildlife reacts to hikers and dogs is limited, although preliminary evidence suggests that presence of dogs increases the response. For example, mountain sheep (*Ovis canadensis*, MacArthur et al. 1979,1982), golden plovers (*Pluvialis apricaria*, Yalden and Yalden 1990), and marmots (*Marmota marmota*, Mainini et al. 1993) exhibited a greater response when pedestrians were accompanied by a dog compared to solitary pedestrians.

Location and frequency of recreational activities also can influence wildlife responses (Knight and Cole 1995). If animals perceive an activity as spatially predictable and nonthreatening, they may habituate to that activity (Whittaker and Knight 1998). For example, humans approaching from a parking area (an area with consistent human use) elicited less of a response from mountain sheep than did humans approaching from over a ridge, where human use was sporadic (MacArthur et al. 1982).

Of the numerous studies on effects of recreational activities on wildlife, most present information on flush distance (the distance between the activity and the animal when it flushes) as the animal is approached directly by humans. Although birdwatchers, photographers, and others do approach wildlife, most recreationists do not go out of their way to do so. Rather, most recreationists, such as hikers walking on trails, do not commonly leave the trail. To investigate this type of disturbance, we correlated an animal's flush response with its perpendicular distance to the trail or line of human movement. With this information, we were able to assess an "area of influence" for each treatment. Area of influence was defined as the probability that an animal will flush or become alert (for mule deer only) at a given perpendicular distance from a trail or line of human movement. The greater the area of influence, the more disturbing the activity is to wildlife. For example, if the probability of flushing for a bird 30 m away from a trail is 0.40 to a pedestrian accompanied by a dog and 0.70 to a pedestrian alone, then the area of influence is greater for the pedestrian alone.

Our objective was to assess the area of influence around a lone pedestrian, a pedestrian accompanied by a dog on leash, and a dog alone, on and off trails. For animals that flushed, we compared information on flush distance (the distance between the activity and the animal when flushed) and distance moved to further assess the magnitude of disturbance for each treatment. Additionally, for mule deer, we compared information on alert distance (the distance between the activity and the deer when it became alert) among treatments. In grasslands, we recorded responses of vesper sparrows and western meadowlarks to all treatments. In forests, we recorded responses of American robins and mule deer to all treatments except the dog alone. For each species, we tested the null hypothesis that the area of influence and magnitude of disturbance did not differ between treatments.

Methods and study area

We conducted our study on 8,000 ha of City of Boulder Open Space property in and around the city of Boulder, Colorado (40°00′N, 105°18′45″E). Elevation within the study area ranged from 1,219 to 2,438 m, encompassing forest, riparian, shrubland, and grassland habitats. Visitor use on City of Boulder Open Space is approximately 2 million visits/year and is greatest during the spring, followed by summer, fall, and winter (Zeller et al. 1993). Recreational activities included hiking, wildlife viewing, exercising pets, jogging, mountain biking, and horseback riding (hunting is not allowed).

We located study sites in pine forests and mixed-grass prairies. Forests were dominated by ponderosa pine (*Pinus ponderosa*) associated with shrubs, grasses, and forbs. Mixed-grass prairies contained a variety of tall, mid-height, and shortgrass species, including little bluestem (*Schizachyrium scoparium*), western wheatgrass (*Agropyron smithii*), blue grama (*Bouteloua gracilis*), and side oats grama (*Bouteloua curtipendula*).

We conducted treatments on trails and, for off-trail sites, on areas >400 m from trails. Trails received frequent use, whereas off-trail sites were used sporadically by recreationists. We located all sites >800 m from urban development, and >400 m from physiographic features such as forest edge, riparian areas, and ridge lines. Trail width was 1.25 $\pm$0.22 m (mean$\pm$1 SE) in the grasslands and 1.17$\pm$ 0.20 m (mean$\pm$1 SE) in the forests.

We collected data between 14 April and 20 July 1996. We rotated visits to on-trail and off-trail sites to avoid repeatedly sampling the same areas. Birds and mule deer were not marked, so we could not assure the same individuals were not multiply sampled.

Grassland

In grasslands, we recorded responses of vesper sparrows and western meadowlarks to 3 activities, on- and off-trail: 1) a pedestrian alone, 2) a pedestrian accompanied by a dog on leash, and 3) a dog alone. We selected these species because of their abundance on the study site, and we were able to obtain adequate sample sizes for statistical comparisons. For treatments involving dogs, we used either a 25-kg or a 40-kg dog. Leash length was 1.8 m. For on- and off-trail dog alone treatments, the dog maintained an approximate distance of 20 m in front of the observer. For dog-alone treatments we assumed that birds were responding to the dog only and not the observer. In no case did the dogs attempt to chase birds.

For on-trail treatments, we detected individual birds on or near the trail ahead of us and proceeded along the center of the trail at approximately 1.5 m/second until the bird flushed or the observer had passed by eliciting no flush response. At that time, the observer stopped momentarily to record: 1) flush response, 2) the perpendicular distance between the bird and the trail, 3) flush distance, and 4) distance moved. On off-trail sites, we located birds on or near our line of movement and proceeded parallel to the bird's position so as to pass by at various distances (0 m to 200 m perpendicular distance). After the bird flushed or the observer passed by eliciting no flush response, we stopped momentarily to record the same information as that for on-trail treatments.

Forest

In forests, we recorded responses of American robins and mule deer, both on- and off-trail, to a pedestrian alone and a pedestrian accompanied by a dog on leash. We selected these species because of their abundance on the study site, and we were able to obtain adequate sample sizes for statistical comparisons. Information for a dog alone was not recorded because we were unable to maintain an adequate distance behind the dog and still assume that robins or deer were responding only to the dog.

We conducted treatments with robins and deer the same as in the grassland trials. For robins, we also measured (to the nearest 1 m) height above the ground (if perched in a tree). For deer, we also recorded: 1) alert response (i.e., lifted its head), 2) alert distance, and 3) time elapsed from when a deer first exhibited a response until it resumed the pre-disturbance behavior. When group size was >1, we recorded information for the first deer to elicit a response. We used a Lietz rangefinder (model 3390) to measure all distances to the nearest 1 m.

Statistical analyses

We used logistic regression (GENMOD procedure, SAS Institute Inc. 1993) to determine whether flush response (and alert response for deer) of individual species was correlated with treatment, perpendicular distance to trail or line of movement, date, time of day, height of bird if perched in tree (for American robins), and group size and sex (for mule deer). For the animals that flushed, we used analysis of variance (SAS Institute Inc. 1988) to compare flush distance among treatments and also distance moved among treatments of individual species. Because we attempted to simulate typical recreationist behavior (i.e., continuing to proceed along the trail or line of movement without stopping), many deer remained alert to our presence until we moved out of their sight. Consequently, mean and SE of time elapsed from when a deer first exhibited a response until it resumed the pre-disturbance activity could not be determined and we did not conduct statistical analysis comparing treatments. For each grassland treatment, we compared flush distance and also distance moved between vesper sparrows and western meadowlarks using *t*-tests (SAS Institute Inc. 1988). We used an $\alpha=0.05$ for all analyses.

Results

Grassland

We conducted 462 and 393 trials for vesper sparrows and western meadowlarks, respectively. For both species, logistic regression models indicated that treatment ($P<0.001$) and perpendicular distance of the bird ($P<0.001$) to a trail or line of movement (for off-trail) were significant predictors of flush response (Figure 1). The shorter the perpendicular distance of a bird to the trail or line of movement, the greater the probability that a bird would flush. For both species, the area of influence was greater for off-trail treatments than for on-trail treatments (Figure 1). For vesper sparrows, on- and off-trail, and also for western meadowlarks on-trail, the dog-alone treatment resulted in a smaller area of influence than the pedestrian-alone or dog-on-leash treatments, which did not differ from each other. For western meadowlarks, area of influence

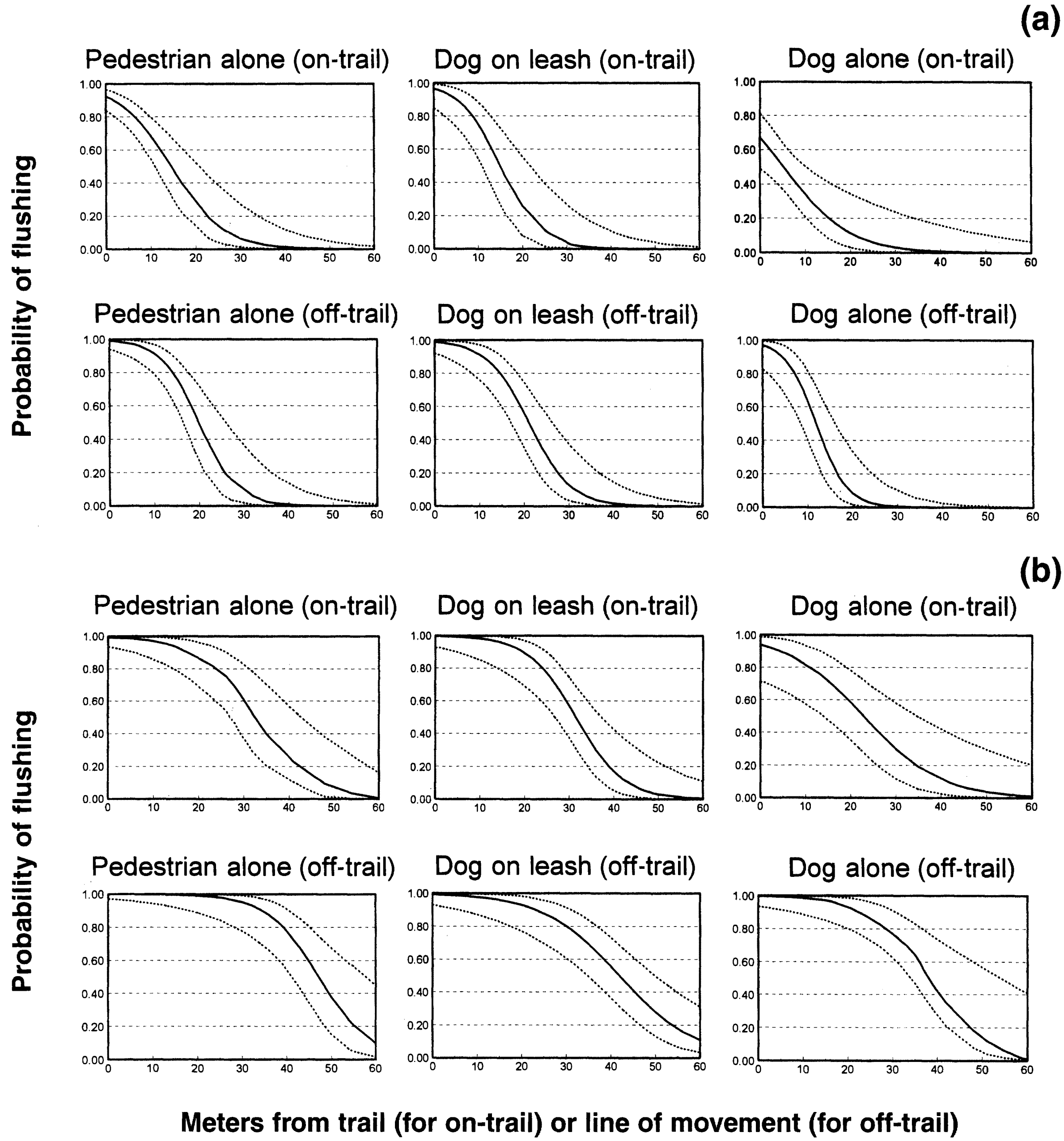


Figure 1. Predicted probability of a vesper sparrow (a) and western meadowlark (b) flushing to treatments in grasslands during 1996, City of Boulder Open Space, Boulder Colorado (dashed lines indicate 95% CI).

did not differ among off-trail treatments. Date and time of day were not significant predictors of whether a bird would flush ($P > 0.05$ for both species).

When vesper sparrows flushed, mean flush distance differed among treatments ($F_{3,269} = 11.75$, $P < 0.001$, Table 1). Flush distance was greater for the off-trail pedestrian-alone and off-trail dog-on-leash treatments than for any other treatment. Other treatments did not differ. For vesper sparrows, distance moved did not differ among treatments ($F_{5,269} = 1.46$, $P = 0.204$, Table 1); however, birds at off-trail sites tended to fly farther when compared to on-trail sites.

When western meadowlarks flushed, mean flush distance differed among treatments ($F_{5,244} = 8.00$, $P < 0.001$, Table 1). For each activity, flush distance was greater for off-trail than on-trail treatments.

Table 1. Mean (SE) of flush distance[a] and distance moved for vesper sparrows and western meadowlarks in grasslands, City of Boulder Open Space, Boulder, Colorado, 1996.

Treatment	Flush distance (m)	Distance moved (m)
Vesper sparrow		
Pedestrian alone (on-trail)	9.25 (0.85)A[b]	43.06 (3.95)A
Dog on leash (on-trail)	10.13 (0.92)A	39.39 (4.56)A
Dog alone (on-trail)	9.89 (1.85)A	35.41 (6.52)A
Pedestrian alone (off-trail)	16.95 (0.87)B	51.49 (5.44)A
Dog on leash (off-trail)	15.11 (0.89)B	52.23 (3.99)A
Dog alone (off-trail)	10.87 (1.16)A	43.43 (5.91)A
Western meadowlark		
Pedestrian alone (on-trail)	30.63 (1.91)A[b]	75.33 (6.55)A,B,C[b]
Dog on leash (on-trail)	28.21 (1.52)A	65.68 (6.09)C
Dog alone (on-trail)	18.78 (2.34)B	91.50 (7.47)B,D
Pedestrian alone (off-trail)	37.73 (2.07)C	95.97 (6.57)D
Dog on leash (off-trail)	36.71 (1.50)C	102.29 (6.73)D
Dog alone (off-trail)	33.50 (2.03)A,C	88.75 (5.38)A,D

[a] Distance between the activity and bird when flushed.

[b] Means with the same letter within a column do not differ ($P > 0.05$).

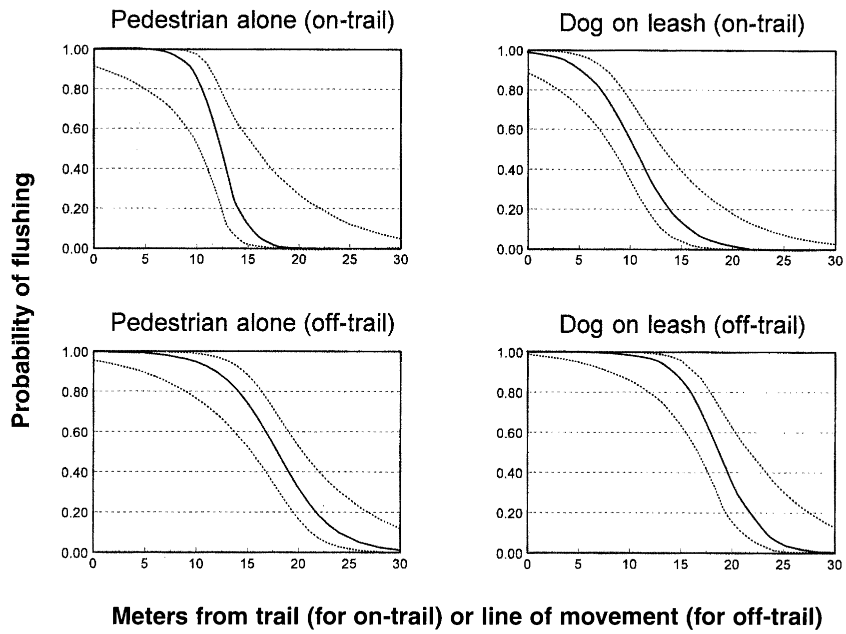
Among on-trail treatments, flush distance was shorter for the dog-alone treatment than either the pedestrian-alone or dog-on-leash treatments, which did not differ. There were no differences in flush distance among off-trail treatments. For meadowlarks, the distance moved after flushing differed among treatments ($F_{5,244} = 3.99$, $P = 0.002$, Table 1). Distance moved was greater for a pedestrian alone and a dog on leash when these activities occurred off-trail vs. on-trail. On- and off-trail dog-alone treatments did not differ. Among on-trail treatments, distance moved differed only between the dog-on-leash and dog-alone treatments, with the latter being greater. There were no differences in distance moved among off-trail treatments.

For each treatment, flush distance was greater for western meadowlarks than for vesper sparrows ($t \geq 2.98$, $P \leq 0.005$) and meadowlarks flew greater distances once flushed ($t \geq 3.40$, $P \leq 0.001$).

Forest

We ran 228 trials for American robins. Logistic regression models indicated that treatment ($P = 0.001$) and perpendicular distance of the bird ($P < 0.001$) to the trail (for on-trail) or line of movement (for off-trail) were significant predictors of flush response (Figure 2). The shorter the perpendicular distance of the robin to the trail or line of movement, the greater the probability that it would flush. The area of influence was greater for off-trail than for on-trail treatments (Figure 2). However, the area of influence did not differ between the pedestrian-alone and dog-on-leash treatments, either on- or off-trail. Date, time of day, and height of bird (if perched in tree) pre-flush were not significant predictors of whether a robin flushed (all $P > 0.05$).

When robins flushed, mean flush distance differed among treatments ($F_{3,129} = 17.92$, $P < 0.001$, Table 2). Flush distance was greater for off-trail treatments than for on-trail, with the greatest flush distance for the off-trail dog-on-leash treatment. Distance moved after flushing also differed among treatments ($F_{3,129} = 3.50$, $P = 0.017$, Table 2). Distance moved was greatest for the off-trail dog-on-leash treatment and shortest for the on-trail pedestrian-alone treatment.



Fiugre 2. Predicted probability of an American robin flushing to treatments in forests during 1996, City of Boulder Open Space, Boulder Colorado (dashed lines indicate 95% CI).

Table 2. Mean (SE) of flush distance[a] and distance moved for American robins in forests, City of Boulder Open Space, Boulder, Colorado, 1996.

Treatment	Flush distance (m)	Distance of Flush (m)
Pedestrian alone (on-trail)	9.61 (0.63)A[b]	14.97 (2.19)A[b]
Dog on leash (on-trail)	9.82 (0.55)A	20.79 (2.09)A,B
Pedestrian alone (off-trail)	13.74 (1.08)B	17.31 (1.85)A,B
Dog on leash (off-trail)	16.27 (0.60)C	23.49 (2.05)B

[a] Distance between the activity and bird when flushed.
[b] Means with the same letter within a column do not differ ($P > 0.05$).

We ran 88 trials for mule deer. Logistic regression models indicated that treatment ($P = 0.003$) and perpendicular distance of the deer ($P = 0.002$) to the trail or line of movement (when off-rail) were significant predictors of alert response (Figure 3). For on-trail treatments, the shorter the perpendicular distance of deer to trail, the greater the probability that it would become alert. The area of influence was greatest for off-trail treatments, where the deer became alert regardless of activity type or their perpendicular distance to the line of movement (Figure 3). On-trail, the dog-on-leash treatment resulted in a greater area of influence than the pedestrian-alone treatment. Deer group size, sex, date, and time of day were not significant predictors of whether a deer would become alert (all $P > 0.05$). When deer did become alert, mean alert distance differed among treatments ($F_{3,72} = 7.97$, $P < 0.001$, Table 3). When comparing each activity individually, there were no differences in alert distance whether the activity occurred on- or off-trail. However, within on- or off-trail treatments, alert distance was greater when a dog was present.

Logistic regression models indicated that treatment ($P < 0.001$) and perpendicular distance of the deer ($P = 0.001$) to the trail (for on-trail) and line of movement (for off-trail) were significant predictors of flush response (Figure 3). The closer the deer was to the trail or line of movement, the greater the probability that it would flush. The area of influence was greater for off-trail treatments than for on-trail (Figure 3). For both on- and off-trail, area of influence was greater when a dog was present. Deer group size, sex, date, and time of day were not significant predictors of whether a deer would flush (all $P > 0.05$).

When deer flushed, mean flush distance differed among treatments ($F_{3,42} = 13.40$, $P < 0.0001$, Table 3). Flush distance was greater for the off-trail dog-on-leash treatment than any other. Because many of the deer that flushed moved out of sight for the off-trail dog-on-leash treatment, we could not calculate mean and SE of distance moved for this treatment. Therefore, we did not include the off-trail dog-on-leash treatment in statistical comparisons of distance moved among treatments. When comparing the other treatments, distance moved differed between treatments ($F_{2,30} = 7.80$, $P = 0.002$, Table 3). Distance moved was greater for the off-trail pedestrian-alone treatment than the on-trail treatments, which did not differ.

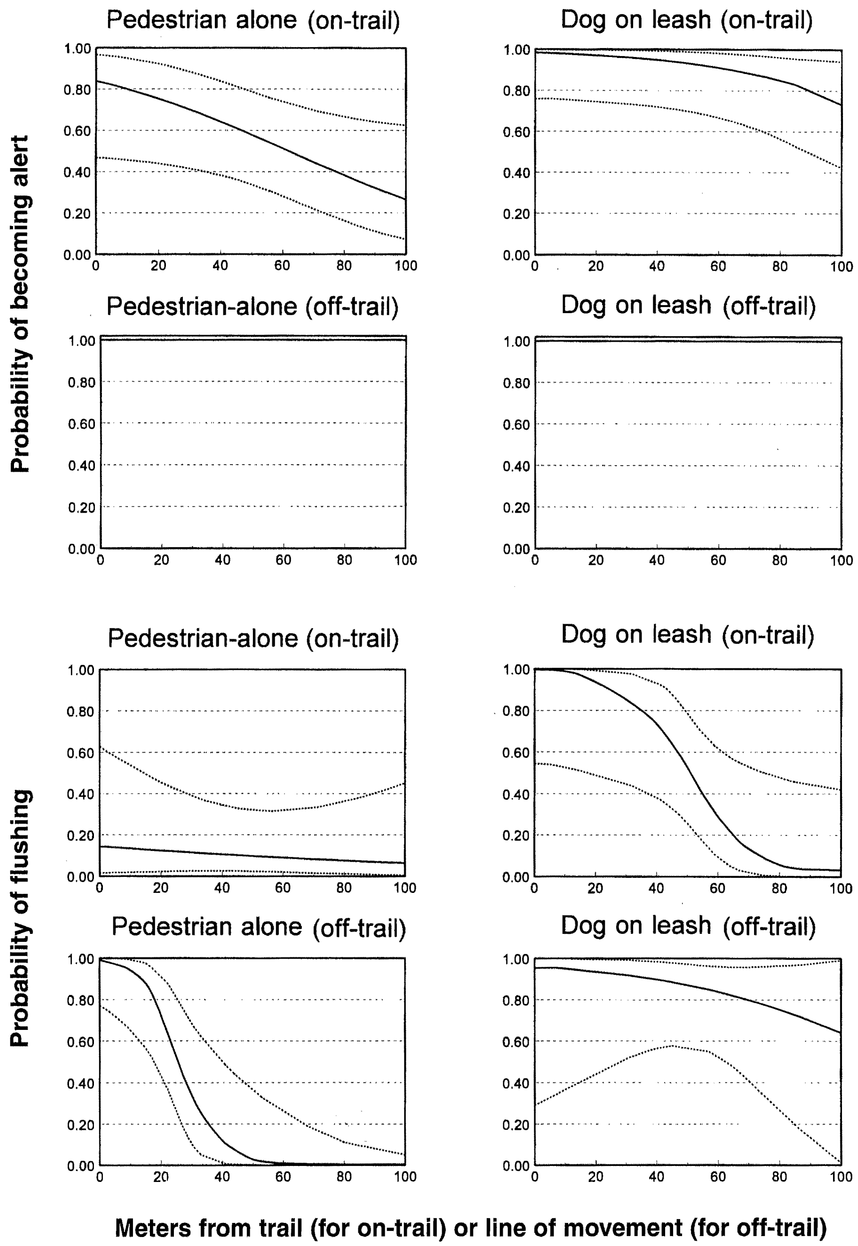
Discussion

Wildlife may exhibit diverse responses to various types of recreational activities and may be influenced by the frequency and spatial context in which the activity occurs (Knight and Cole 1995). In general, for vesper sparrows and western meadowlarks, the flush distance and distance moved was shortest and the area of influence was smallest for dog-alone treatments and greatest when a pedestrian was present. Because dogs closely resemble coyotes (*Canis latrans*) and foxes (*Vulpes fulva*) and because these species are typically not considered significant predators on song-

Table 3. Mean and SE of alert distance[a], flush distance[b], and distance moved[c] for mule deer in forests, City of Boulder Open Space, Boulder, Colorado, 1996.

Treatment	Alert distance (m)	Flush distance (m)	Distance moved (m)
Pedestrian alone (on-trail)	45.55 (12.75)A[d]	33.50 (0.50)A[d]	31.50 (1.50)A[d]
Dog on leash (on-trail)	85.37 (8.13)B,C	48.50 (3.75)A	35.89 (5.96)A
Pedestrian alone (off-trail)	66.77 (4.34)A,B	34.19 (4.63)A	77.0 (9.61)B
Dog on leash (off-trail)	100.60 (7.81)C	81.92 (7.85)B	(>76 – >300)[e]

[a] Distance between the activity and deer when it became alert.
[b] Distance between the activity and deer when it flushed.
[c] Mean and SE could not be determined because some deer moved out of view for the dog on leash treatment, therefore this treatment was not included in the analysis.
[d] Means with the same letter do not differ ($P > 0.05$).
[e] Indicates range of distance moved before deer moved out of view.



Fiugre 2. Predicted probability of an American robin flushing to treatments in forests during 1996, City of Boulder Open Space, Boulder Colorado (dashed lines indicate 95% CI).

birds (Leach and Frazier 1953, Andelt et al. 1987), these bird species may not have perceived dogs as an important threat. Alternatively, dogs may pose a different kind of threat than a pedestrian and birds may hold their position until the last moment, attempting to remain undetected. Because the area of influence was generally the smallest for the dog-alone treatments and because there were no significant differences between the pedestrian-alone and dog-on-leash treatments, it appears that presence of a pedestrian is the additive factor. This is further supported by the fact that the area of influence did not differ between the pedestrian-alone and dog-on-leash treatments for American robins in the forest, either on- or off-trail.

For all species in our study, area of influence, flush distance, and distance moved were almost always greater when activities occurred off-trail versus when the same activity occurred on-trail. Recreational use occurred on our off-trail study sites but was sporadic; conversely, recreational use on trails was common (City of Boulder Open Space 1996). Because recreational activities occurring on-trail were frequent and spatially predictable, animals had likely habituated to activity in these locations. Off-trail recreation, however, was infrequent and spatially unpredictable. Thus, animals were not accustomed to activity in these areas, resulting in the greater area of influence, flush distance, and distance moved. In Switzerland, a study of marmots revealed similar results (Mainini et al. 1993). They found that marmots exhibited the greatest response to hikers when hikers strayed away from trails. Cooke (1980), Yalden and Yalden (1989), Burger and Gochfeld (1991), and Kenny and Knight (1992) showed that in areas where human activity was common and frequent, birds were less disturbed than those in areas where humans were uncommon. Likewise, Schultz and Bailey (1978), MacArthur et al. (1982), and Hamr (1988) found that large mammals exhibited the greatest response when human activity was spatially unpredictable.

Unlike the responses of bird species in our study, mule deer exhibited the greatest response when a dog was present. Similar to our results, MacArthur et al. (1979, 1982) and Mainini et al. (1993) found that mountain sheep and marmots, respectively, exhibited heightened responses when dogs were present. Although City of Boulder Open Space regulations require that dogs be under voice control, there were no leash laws on our study sites and dogs are known to harass and attack deer (personal observation). Because dogs can kill deer (Bowers 1953, Barick 1969, Lowry and McArthur 1978) and because canids have preyed on deer throughout their evolutionary history, we assume that deer have become sensitized to the presence of dogs, explaining the greater reaction when a pedestrian was accompanied by a dog.

For the species measured in our study, the area of influence was smaller when treatments occurred on-trail than off-trail. However, all species appeared to have a threshold of tolerance to disturbance based on distance, with a greater flush response (and alert response for mule deer) when wildlife were close to trails. An earlier study on the same area revealed a positive correlation between abundance of some bird species, nest occurrence, and nest success with distance from trails (Miller et al. 1998). The authors felt that this correlation was in part a result of recreational activity and the associated disturbance. Even though the area of influence for all species was smaller on-trail versus off-trail, on-trail activities may still constitute an important source of disturbance. Thus, our results suggest that human activities may displace wildlife and reduce fitness in local wildlife populations. As mentioned earlier, off-trail recreational use was sporadic. However, should recreational use away from trails increase, displacement of wildlife may ultimately result. Experiments conducted in forested areas of Wyoming without trails support this conclusion (Gutzwiller et al. 1994, Riffell et al. 1996, Gutzwiller et al. 1997), showing that recreational activities away from trails resulted in altered behavior and displacement of birds.

Management implications

Land managers can use spatial and behavioral restrictions in visitor management to ensure coexistence of wildlife and recreationists (Knight and Temple 1995). Because off-trail treatments resulted in the greatest area of influence for all wildlife in this study, recreational use could be restricted (through education and enforcement) to trails as a way to reduce impacts. However, because negative impacts occur even from on-trail use, number and spatial arrangement of trails must be considered in conservation planning. Furthermore, because type of recreational activity influenced the magnitude of wildlife response, managers could restrict certain recreational activities, such as prohibiting dogs in some areas or requiring dogs to be leashed. Partitioning the landscape into recreation zones, allowing certain activities in some zones while restricting them in others, may aid in reducing conflicts with sensitive species.

People are often not aware of how their activities affect wildlife, even if they see animals respond to their actions (Stalmaster and Kaiser 1998). Even though the dog-alone treatment resulted in the smallest area of influence for grassland birds in our study, area of influence will increase if recreationists allow their dogs to roam away from a trail. Additionally, in our study we did not stop and view the subjects for extended periods of time or attempt to move toward them. Behaviors of this kind are common among nature viewers and could lead to elevated wildlife responses (Klein 1993).

Recreationists are more likely to support restrictions if they understand how wildlife will benefit (Purdy et al. 1987, Harris et al. 1995). By emphasizing how human activities affect wildlife, people can associate their actions with either benefiting or harming animal populations and begin to develop a conservation ethic. Such an ethic can minimize the number of wildlife-human conflicts occurring in natural areas (Knight and Temple 1995). Klein (1993) found that visitors who spoke to wildlife refuge personnel were less likely to disturb wildlife than recreationists who did not. Thus, effective visitor education can aid in developing a conservation ethic. Through education, land managers can inform recreationists of how their activities affect wildlife and how they can modify their behavior to minimize impacts.

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