MEETING OF THE BOARD OF COUNTY COMMISSIONERS
BOULDER COUNTY, TUESDAY, MARCH 14, 2006

The Board of County Commissioners of Boulder County met in regular session in full conformity with the law and resolution of said Board at the regular place of meeting in the Office of the Board of County Commissioners, Third Floor, Courthouse, Boulder, Colorado, on Tuesday, March 14, 2006.

The meeting was called to order at approximately 10:33 a.m. by Chair Pearlman with the following present:

Ben Pearlman, Chair
Thomas A. Mayer, Vice Chair
Will Toor, Commissioner (excused until 11:00 a.m.)

[excerpt from minutes – but this item is in its entirety]

5:00 P.M.
PRESENTER: Parks and Open Space Department
Public Hearing: Dog moratorium on the Hall Ranch and Heil Valley Ranch open space properties (Rescheduled from 3/9/06); Parks and Open Space staff will recommend that the current dog moratorium at Heil Valley Ranch and Hall Ranch open space properties be a permanent policy.
(5:05 – 7:26) (24:10, Tape No. 15/DAT recorder, "counter" mode)

Legal notice was published in the newspaper of record in accordance with the statutory or regulatory requirements pertaining to this matter.

Presenters: Therese Glowacki, Parks and Open Space Division
Ben Lenth, Parks and Open Space Division
David Bell, Lead Ranger, Parks and Open Space Division

Present: Barbara Andrews, Assistant County Attorney

Speakers: Linda Andres-Georges, 8417 Stirrup Lane, Longmont
Stephen Jones, 3543 Smuggler Way, Boulder
Carol Kampert, 3060 Ash Ave., Boulder
Peter Baumgartner, P.O. Box 1822, Lyons
Larry Elmore, 1008 Steamboat Valley Rd., Lyons
Roger Flynn, 1010 Steamboat Valley Rd., Lyons
Kirk Cunningham, 977 7th St., Boulder
Ed Mills, 2996 29th St., Boulder
Lori Fuller, 2995 Carnegie Dr., Boulder
Karen Hollweg, 4440 Greenbriar, Boulder
Mimi Elmore, 1008 Steamboat Valley, Rd., Lyons
Dan Sukle, 2637 5th St., Boulder
Chris Morrison, 4100 Aurora Ave., Boulder
Penni Parr, 1386 Bonner Circle
Eric Vogelsberg, 1345A Bear Mtn. Dr., Boulder
Madeline Goldhawk, 2645 Table Mesa Ct., Boulder
Patrick Murphy, 1554 North St., Boulder

ACTION

Commissioner Mayer moved to not allow dogs at Hall & Heil Valley open spaces and to instruct staff to continue to do research and investigate other options for dog walking activities in the areas around Lyons. Commissioner Toor seconded the motion.

VOTE: PEARLMAN, aye; MAYER, aye; TOOR, aye. Motion carried 3-0. (1:33:21)

Boulder County

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Parks and Open Space Department

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approved 3/14/06 by BOCC

TO: Board of County Commissioners

DATE AND LOCATION: Tuesday, March 14, 2006, 5:00 pm, Commissioners Hearing Room, 3rd floor Boulder County Courthouse, 1325 Pearl Street, Boulder, CO

AGENDA TITLE: Dogs on North Foothills Open Space

PRESENTER: Therese Glowacki, Resource Manager, Boulder County Parks and Open Space

ACTION REQUESTED: Decision

Purpose

The purpose of this meeting is for the Board of County Commissioners to make a decision regarding the moratorium on dogs at the North Foothills Open Space properties (Hall Ranch and Heil Valley Ranch). Staff recommends making this a permanent policy.

Introduction

The Mission of Boulder County Parks and Open Space is to conserve natural, cultural and agricultural resources and provide public uses that reflect sound resource management and community values. This is the guiding principle staff used in reviewing the dog moratorium on the North Foothills Open Space properties. Finding a balance between conserving natural resources and providing public uses is often complex. There are conflicting values within the community we serve and relatively few scientific studies that have evaluated the interaction between recreation and natural resources. In reviewing the existing dog moratorium policy, we examined both the available science on conserving the valuable wildlife found on these properties and the community values of both the users of open space and the community at large.

Background

The North Foothills Open Space properties are among the most biologically diverse areas in Boulder County. The North Foothills Open Space Management Plan notes that the foothills life zone and ecotone with the plains is considered rich habitat for mammals. Approximately 60 species of mammal could call the North Foothills Open Space home. This represents about 70% of all mammal species found in the County. In addition, a total of 97 potential breeding bird species were observed during one season's survey on the North Foothills Open Space. Of this total, nests or other evidence of breeding was

confirmed for 47 species. This is a primary reason why there has been a dog moratorium on the North Foothills Open Space properties since in 1997.

In the spring of 1997, the North Foothills Advisory Committee presented three dog management proposals to the Parks and Open Space Advisory Committee (POSAC) and the Board of County Commissioners (BOCC). POSAC voted 9 to 2 in favor of continuing the moratorium until 1999, completing wildlife studies, and only considering dog access to Hall and Heil Valley Ranches if a 90% compliance rate was achieved on all Parks and Open Space (POS) properties. BOCC agreed to aiming for the target compliance rate, undertaking a public education campaign, increasing enforcement, completing the Hall Ranch trail systems and continuing wildlife monitoring before making a definitive ruling on the dog ban. From 1997 through 2000, POS staff tracked leash compliance, worked aggressively on a public education initiative, and increased enforcement.

In 2000, with support from approximately half the North Foothills Advisory Committee, POSAC approved the permanent implementation of prohibiting dogs on Hall and Heil Valley ranches. The Board of County Commissioners (BOCC) extended the dog moratorium for 5 years with the recommendation that staff continue to study the impacts of dogs on wildlife and the leash compliance.

For the past 5 years, POS staff has continued to monitor leash compliance throughout the system, study and track wildlife on these properties, continue education and enforcement, and survey visitors on their perspective of the dog moratorium on these properties. POS has also opened two properties where dogs are permitted off-leash: Reynolds Ranch and Twin Lakes.

POS staff understands that many citizens of Boulder County and users of open space value the ability to bring their dogs with them while on open space property. This is something staff has taken into account in reviewing the status of the dog moratorium on the North Foothills property, trying to find a balance between recreation and wildlife.

Following is an update on the various aspects requested by the BOCC and the staff recommendation regarding continuing the dog moratorium on these two properties.

Leash Law Compliance: In 2005, overall leash compliance was 82%. This is an increase from 1999, when overall leash compliance was 77%. On the foothills properties (Walker Ranch, Betasso Preserve, Rabbit Mountain and Anne U. White Trail), properties that are similar to the North Foothills Open Space, compliance is lower. In 1999 it was 76% and in 2005 it was 77%.

The North Foothills Open Space properties jointly have a minimum of 100,000 visitors per year. In our five-year Visitor Study conducted at all POS parks and neighbor trails open to the public in 2005, 20% of visitors had at least one dog with them. Therefore, we estimate that 20,000 dogs per year would accompany their owners to Hall and Heil Valley Ranches if dogs were permitted. Based on this figure and an 18% rate of non-

compliance, approximately 3,600 dogs per year would be found off leash on these properties.

Wildlife Studies: POS Wildlife staff has continued to monitor wildlife on the North Foothills properties with our own inventories and through collaborative research with CU and CSU. Staff, in conjunction with the Division of Wildlife, continues to track the elk on Heil Valley Ranch. Recorded observations of elk on Heil Valley Ranch show that since the Ponderosa Loop and Wapiti trail opened on this property, the elk use has shifted to the east to avoid contact with trail users. Overall herd numbers have remained the same for the past 5 years.

Dr. Alexander Cruz from CU conducted a long-term study of Heil Valley Ranch entitled "Effects of Forest Management and Trail Use on Ponderosa Pine Forest Birds on Heil Valley Ranch, Boulder County Open Space". This study compares the nesting ecology and relative abundance of several bird species under pre-trail and post-trail conditions. The research sites are also in an area where forest thinning is ongoing to improve habitat for all species. The data of this five-year study suggested that most species do not appear to be showing a decline in use of these sites as currently allowed recreational use increases. Chipping Sparrow, Lesser Goldfinch, Pygmy Nuthatch, and Western Wood pe-wee all showed an increase between 1999 and 2003. The exceptions were American Robins, Mountain Chickadees, and Stellar's Jays. In addition, researchers noted a lower number of nesting birds around the parking lot and picnic areas after the trail opening. Nesting success showed a drastic drop in several species including American Robin, Lark Sparrow, Mourning Dove and Plumbeous Vireo. The study data showed that existing types of recreation might be compatible with a healthy bird community on Heil Valley Ranch. However, they caution that nesting success should be closely monitored to ensure that the overall success of the bird community is not negatively affected by future human influences.

A study conducted by Clint Miller and Dr. Richard Knight on City Of Boulder Open Space published in 2001 found dogs increase the flushing distances of mule deer, Vesper Sparrows, Western Meadowlarks and American Robins, and that the flushing distance generally increases when dogs accompany humans off-trail.

Finally, we contracted with Dr. Richard Knight and Ben Lenth from CSU to do a comparison study of wildlife on foothills properties with recreation where dogs were allowed (City of Boulder) and where dogs were prohibited (North Foothills Open Space). This study quantified the effects of dogs on wildlife communities by comparing the activity levels of wildlife between trails that allow dogs off-leash under "voice and sight" control, with trails that prohibit dogs. Four methods were used on trail and up to 200 m off-trail: scented tracking plates, pellet surveys, remoter triggered cameras, and on-trail scat surveys. Additionally, they measured the distances of prairie dog burrows to several different trails with the same dog policies. Results indicate that habitat utilization by several species is significantly different along recreational trails where dogs are allowed. Mule deer are less prevalent along trails that allow dogs at least 100m further than with trails that prohibit dogs. Small mammals, including squirrels, rabbits, chipmunks and

mice, are less prevalent along trails with dogs by at least 50m. Also, the density of prairie dog burrows is decreased within 25m of trails that allow dogs. Carnivores may also be affected. Red fox detections were much higher when dogs were present, and bobcat detections were much lower. The full results of this study will be presented at the public hearing and is found in Attachment A.

Visitor and Public Opinion: POS regularly conducts visitor studies to gather information from users regarding management of open space. In 2004, POS staff conducted a study of visitor attitudes about having the Hall and Heil Valley Ranches closed to dogs. The study was conducted on Hall Ranch, Heil Valley Ranch and Rabbit Mountain. On Hall Ranch, 69% of visitors supported the regulation prohibiting dogs; on Heil Valley Ranch, 63% of visitors supported the regulation. On Rabbit Mountain where dogs are allowed, only 44% of visitors supported the regulation at Hall and Heil Valley Ranches.

In our 2005 five-year system-wide Visitor Study, 66% of visitors supported restricting dogs on some trails to protect wildlife, and 18% didn't support it.

Of dog owners in both studies, 50% from the Hall/Heil/Rabbit Mountain Study and 55% from the five-year Visitor Study support restricting dogs on some trails to protect wildlife. Dog owners in the first study cited ecological concerns, keeping the properties dog free and balanced use as their reasons for supporting the policy. On the Hall and Heil Valley Ranches, 39% of dog owners don't support the restriction. (Overall 43% of visitors own a dog, 55% don't own a dog.)

Finally, in the 2002 public attitude telephone survey conducted in the County of registered voters, 75% of those surveyed support closure of trails to dogs in sensitive areas in order to minimize impacts to wildlife and the ecosystem. Only 10% oppose this.

Other Land Management Agencies: In a survey of 10 land management agencies (5 within Colorado and 5 from other states) conducted by the City of Boulder, they found an average of 75% of lands open to the public required dogs to be on leash; 13% of the lands allowed dogs to be off leash and 13% of the lands prohibited dogs.

In Boulder County, Rocky Mountain National Park permits dogs on leash in developed areas only, not on natural surface trails. The US Forest Service has mixed regulations regarding dogs, establishing some areas where dogs must be leashed and others where dogs can be unleashed. The City of Boulder has recently adopted a visitor master plan that has a variety of dog regulations from continuing their voice and sight control on many properties to some properties where dogs are prohibited to protect wildlife. Maps depicting Boulder County trails that don't allow dogs, trails that allow dogs and other public lands that provide the opportunity for people to recreate with their dogs is in Attachment B.

have hiking areas without having conflicts with dogs on trails, we recommend the dog moratorium become permanent policy for the North Foothills Open Space.

POSAC Action: On February 23, 2006, the Parks and Open Space Advisory Committee recommended to the Board of County Commissioners to support the staff recommendation of making the dog moratorium on North Foothills Open Space a permanent policy by a vote of 7 to 1.

Attachments:
(http://www.co.boulder.co.us/openspace/management_plans/north_foothills/Dog_moratorium_2006/dogs_nfos.htm)

A. *The Effects of Dogs on Wildlife Communities*, Benjamin Lenth, Colorado State University, February 2006 (http://www.co.boulder.co.us/openspace/management_plans/north_foothills/Dog_moratorium_2006/dogs_nfos.htm)
B. Map of trails in Boulder County that allow dogs
C. Letter from the Colorado Division of Wildlife

The Colorado Division of Wildlife has recommended that the North Foothills Open Space be kept dog free for wildlife habitat. They site in particular the potential negative impacts to nesting raptors and elk on those properties (Attachment C).

Boulder County: Boulder County POS has 90 miles of trail. On Hall and Heil Valley Ranches there are 20 miles of trail, and Caribou Ranch, the only other POS property that does not allow dogs, has 3 miles of trail. This represents 26% of the total trail mileage managed by the Department that a visitor cannot bring a dog. Two properties permit dogs off leash, Reynolds Ranch near Nederland and one lake at Twin Lakes. Overall, 80% of visitors to Boulder County's open space don't bring dogs with them to POS properties.

User Conflicts: In 2003, POS staff conducted a conflict study. We found 2% of visitors reported conflict on the day they were surveyed. In the five-year Visitor Study, 9% of visitors had experienced interpersonal conflict within the past year on the properties. From the conflict study, when questioned about the nature of the conflict, 16% of the comments were regarding dog walkers: either dogs being off leash, dog owner's control of the dog, or dog feces. This was the second largest category that caused conflict, following mountain bikers at 52%.

Staff Recommendation: The North Foothills Open Space is one of our most wildlife rich properties, comprising an ecological transition zone between shortgrass prairie and montane habitats. While leash law compliance rates have increased, there are still many reasons for maintaining the dog moratorium on Hall and Heil Valley Ranches.

First is the impact dogs may have on wildlife. The rich bird life, elk herd, mountain lions and bobcats that use the North Foothills could be negatively impacted by the introduction (or re-introduction) of dogs on these properties. The study conducted by Ben Lenth is indicative of the potential for negative wildlife impacts from domestic dog presence in this habitat. Longer studies may be conducted to further investigate the trends noted by these researchers. However, if the dog moratorium is lifted on these two properties, their function as the only recreational dog-free control sites in the foothills of Boulder County will be lost for future research opportunities.

Second, public opinion clearly supports restricting dogs on properties for wildlife protection, with even half or more of dog owners supporting this. As shown in the study of users of Hall and Heil Valley Ranch, people using the properties support the restriction by more than a 2 to 1 margin.

Finally, we feel that the county provides a variety of recreation opportunities, including many trails where dogs can accompany their owner on-leash, a couple of trails where dogs are allowed off-leash, and these two properties and Caribou Ranch where dogs have been prohibited. There are also many other trails throughout Boulder County, managed by other agencies, where dogs are permitted. For protecting the valuable wildlife habitat that Hall and Heil Valley Ranches offer, and the opportunity for the recreating public to

The Effects of Dogs on Wildlife Communities

Benjamin Lenth[1*], Mark Brennan[2], and Richard L. Knight[3]
February, 2006

Final research report submitted to:
Boulder County Open Space and Mountain Parks

[1] Graduate Degree Program in Ecology, Colorado State University
[2] Boulder County Parks and Open Space
[3] Department of Forest, Rangeland, and Watershed Stewardship, Colorado State University
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Abstract

Domestic dogs (*Canis familiaris*) are frequent visitors to open space areas, though little is known about their ecological impacts. We studied the effects of dogs on wildlife by comparing the activity levels of wildlife in areas that prohibit dogs, with areas that allow dogs off-leash under "voice and sight" control. To measure wildlife activity both on trail and up to 200 m off-trail, we used four methods: pellet surveys, scented tracking plates, remote triggered cameras, and on-trail scat surveys. Additionally, in prairie dog (*Cyonomys ludocivianus*) colonies we measured the distances of prairie dog burrows to the nearest trail, and compared the density of prairie dog burrows between areas with and without dogs. The presence of dogs along recreational trails correlated with altered patterns of habitat utilization by several wildlife species. Mule deer (*Odocoileus hemionus*) activity was significantly lower in proximity to trails in areas that allow dogs, and this effect extended at least 100 m off-trail. Small mammals, including squirrels (*Sciurus spp.*), rabbits (*Sylviagus spp.*), chipmunks (*Eutamias spp.*), and mice (*Peromyscus spp., Reithrodontomys spp., Onychomys spp., Zapus spp.*), also exhibited reduced levels of activity in proximity to trails in areas with dogs, and this effect extended at least 50 m off-trail. Furthermore, the density of prairie dog burrows was lower within 25 m of trails in areas that allow dogs. The presence of dogs also affected carnivore activity, although in varying ways. Red fox (*Vulpes vulpes*) detections were higher in areas that allowed dogs, and bobcat (*Felis rufus*) detections were lower. These findings have implications for the management of natural areas regarding dog policies, particularly those that allow dogs off-leash.

Introduction

Domestic dogs (*Canis familiaris*) are ubiquitous in American society, yet we know relatively little about their ecology or interspecific interactions with wildlife. Numbering approximately 400 million worldwide, with 61.6 million in America alone, domestic dogs far outnumber all other canids combined (Coppinger and Coppinger 2001, U.S. Pet Ownership and Demographics Sourcebook 2002). The vast majority of dogs in the U.S. are owned as pets, though some range freely, and some are feral.

Outdoor recreation in North America is growing rapidly in popularity, and this trend is expected to continue in the coming decades (Flather and Cordell 1995), with a variety of impacts on wildlife (for a review see Knight and Gutzwiller 1995). Dogs often accompany recreationists, necessitating policies that manage the perceived impacts of dogs on protected lands. Often, leash laws restrict dogs to trails and limit their interaction with other dogs, people, livestock and wildlife. Little scientific data exists to justify these policies in terms of ecological impacts. When dogs accompany recreationists on trails, their activity is usually concentrated along a relatively narrow corridor within a natural setting, providing a unique opportunity to examine their effects on wildlife.

Increasing numbers of dogs in natural areas could have varied and complex ecological effects, potentially influencing community dynamics in myriad ways including indirect effects that could cascade down through trophic levels (Kay 1998). Dog's closest relative, the gray wolf (*Canis lupus*) has demonstrated disproportionate ecological impacts that can cascade through ecosystems, affecting plants, animals, and ecological processes (Smith et al. 2003). In addition to direct ecological effects through predation, increased activity by wolves in Yellowstone has caused elk (*Cervus elaphus*) to avoid willow thickets, where the limited visibility increases their susceptibility to ambush. Here, the mere *possibility* of wolf predation can change patterns of habitat utilization by elk and other ungulates, allowing willows to regain vitality and support a host of other species (Ripple and Beschta 2004). Dogs are inefficient hunters, and could not regulate ecosystems with the efficacy of wolves (Serpell 1995). However, dogs are avid chasers, and through chasing could displace wildlife from their habitats, particularly when certain species, such as deer, perceive dogs as predators and avoid areas where they could be chased. Ungulates and herbivores are thus susceptible to disturbance by dogs, additive to

predation pressures already present by native carnivores such as mountain lions (*Felis concolor*) and coyotes (*Canis latrans*).

Dogs and native carnivores rarely have opportunities to interact directly, but may interact indirectly through scent marking (Bekoff 1979). Indirect interactions could either displace or attract carnivores depending upon the perceived competition or threats dogs offer. Carnivores determine and identify territories primarily through olfactory cues, and recognize and avoid areas scent-marked by other individuals or packs (Gorman and Towbridge 1989, Pal 2003). Recreational trails with abundant dog scent could appear to carnivores to be linear dog territories, necessitating increased caution and possibly deterring their activity. However, the interaction could have the opposite effect on certain carnivore species. Carnivore activity is sometimes elevated along portions of territories, such as boundaries, where they encounter novel stimuli and invest considerable time in territorial surveillance and maintenance (Allen et al. 1999). Along a busy trail that consistently provides novel scents from different dogs, carnivores could increase their activity investigating and marking. Such opportunities may arise particularly often due to carnivores' propensity to travel along trails, which often present the easiest route in rough terrain (Kevin Crooks, pers. comm.). Thus, as dogs could potentially attract or repel native carnivores, the indirect effects of dogs on carnivore activity is difficult to predict and is likely species-specific. The repercussions of carnivore disturbance can be disproportionately important to the structure and function of ecosystems (Estes 1996).

In this study, we investigated the indirect effects of the presence of dogs on wildlife activity. We wanted to know if the presence of dogs in natural areas influenced the activity of wildlife, and if so, how far the effects of dogs extended from their location. To do this, in 2004 and 2005 we compared the activity levels of mammals on two open spaces in Boulder County that prohibit dogs, with two areas that allow dogs off-leash under "voice and sight control". We selected trails with roughly equal levels of recreational use, and randomly located transects along these trails. To create indices of wildlife activity for comparison across these two policies, we used four methods: track plates, pellet plots, scat transects, and remote-triggered cameras. Dog activity was also sampled with these methods to ascertain their spatial distributions on open space. Camera stations and scat transects were performed on the trails only, and track plates and pellet plots were

performed within three distance categories perpendicular from the trail: 0-5 m, 50-100 m (randomly selected), and 150-200 m (100 m beyond the second plot). Before describing our study, we provide a comprehensive summary of the existing literature on dog ecology.

Previous literature on dog ecology

Studies of domestic dog ecology include both free-ranging and pet dogs in the United States and overseas, and focus on direct interactions with wildlife and the transmission of diseases. The earliest article expresses concerns with free-ranging dogs in the southeastern U.S. and their capacity to harass and kill deer, spread rabies, and eat small mammals and birds (Giles 1960). Later field studies in the same region demonstrated that dogs chased deer (Sweeney et al. 1971), sometimes leading to deer mortality through direct attacks or exhaustion (Corbett et al. 1971). Other researchers have found similar results with pet dogs in Virginia (Gavitt et al. 1974), Indiana (Olson 1974), Arkansas (Gipson et al. 1977) and Idaho (Lowry and McCarthur 1978). Concerns over such attacks led Denny (1974) to conduct a survey of state wildlife agencies, agricultural agencies, and zoos, regarding the costs of uncontrolled dogs. The responses were guesses rather than systematic evaluations, but reported unusually high impacts (e.g., 5000 annual deer moralities caused by dogs in Kansas). Gentry (1983) used these data are used as the primary source for the sensationalist book *When Dogs Run Wild*. Other reports questioned the severity of the impacts of dogs on deer populations (Perry and Giles 1971). However, in Florida, the endangered Key deer (*Odocoileus virginianus clavium*) is particularly susceptible to attacks by free-ranging dogs due to its small size (U.S. Fish and Wildlife Service 1999). Also in the southeastern U.S., feral dogs have been observed to form packs, behave aggressively, and eat small mammals, garbage, and vegetative material (Scott 1973). Prey can include the endangered gopher tortoise (*Gopherus polyphemus*) in Alabama (Causey and Cude 1978). Dogs are also resilient scavengers in urban areas as Beck (1973) documented in a study of stray dogs in Baltimore, Maryland.

Overseas and in certain areas of the U.S., dogs that live in rural villages are commonly free-ranging but derive much of their nutritional needs from people's leftovers and waste. In the southwestern U.S., numerous feral and abandoned dogs clustered their activity and home ranges at garbage dumps (Daniels and Bekoff 1989). When villages

border protected areas, dogs are known to roam inside the borders of such areas, competing with scavengers and carnivores in Zimbabwe (Butler and Du Toit 2002) and wolves (*Canis lupus*) in Italy (Boitani 1983). Also within protected areas, dogs are known to eat wombats (*Vombatus ursinus*) and wallabies (*Macropus rufogriseus* and *Wallabia bicolor*) in Australia (Tiggs et al. 1984), marine iguanas (*Amblyrhrynchus cristatus*) in the Galapagos Islands (Kruuk and Snell 1981, Barnett and Rudd 1983), wild turkeys (*Meleagris gallopavo*) in the United States (Miller and Leopold 1992), capybaras (*Hydrochoerus hydrochoerus*) in Venezuela (McDonald 1981), and the endangered golden langur (*Trachypithicus geei*) in India and Bhutan (Medhi et al. 2004). In a nature reserve in Isarel, dogs are known to chase Nubian ibexes (*Cpara ibex nubiana*) and rock hyraxes (*Procaviacapensis syriaca*) (Brickner 2002). Dog home ranges average 57.8 ha in Italy (Boitani and Ciucci, 1995), and can be over 900 ha for transient dogs in protected areas in southeast Australia (Meek 1999).

Dog interactions with other carnivores are highly variable and sometimes fatal. Anecdotes of dogs both attacking and being attacked by other carnivores are abundant. Documentation includes wolves attacking dogs in Finland (Kojola et al. 2004) and Alaska (Gipson 1983), dogs killing coyotes (*Canis latrans*) (Kamler et al. 2003), and coyotes, lynx (*Lynx canadensis*), and leopards (*Pantherinae panthera*) killing dogs (Palomares and Karo 1999). In one bizarre report, a pack of black squirrels (*Spermophilus dauricas*) killed a stray dog in Russia's Maritime Territory (BBC News 2005). In Alaska, feral dogs vigorously scent-marked spots previously marked by wolves and coyotes (Gipson 1983). Dogs are also known to interbreed with coyotes and wolves (Mengel 1971).

For wildlife populations, the greatest consequences from interactions with dogs may come from the role dogs play as a vector for the transmission of disease. In a review, Sime (1999) notes that dogs are a potential vector for canine distemper, rabies, parvovirus, plague, giardia, and muscle cysts. Dogs have been implicated in transmitting rabies to two species of jackals (*Canis spp.*) in Zimbabwe (Rhodes et al. 1997), canine distemper to lions (*Panthera leo*) in Tanzania (Cleveland et al. 2000) and African wild dogs (*Lycaon pictus)* in Kenya (Alexander and Appel 1994), and rabies, canine distemper and parvovirus to the highly endangered Ethiopian wolf (*Canis simensis*) (Laurenson et al. 1998). In Ethiopia, dogs also interbreed with wolves, diluting their genetic stock and further imperiling their

survival (Laurenson et al. 1997). In Zimbabwe, Butler et al. (2004) note that free-ranging dogs are the most common carnivore in a communal land bordering a reserve, where they are often preyed upon by native carnivores, creating positive conditions for disease transmission. Recently, threatened gray wolves (*Canis lupus*) in Yellowstone National Park have suffered an epidemic of parvovirus or canine distemper, believed to have been transmitted by dogs (Smith 2006, Doug Smith, pers. comm.).

Examinations of dog ecology along recreational trails are most relevant to this study. MacArthur et al. (1979, 1982) found that dogs increased the flushing distance and heart rates of bighorn sheep (*Ovis canadensis*) in Canada. In Great Britain, dogs increased the sensitivity of breeding golden plovers (*Pluvialis apricaria*) in proximity to trails (Yalden and Yalden 1989). Along trails in Switzerland, dogs increased the flushing distances for marmots (*Marmota marmota*), particularly when on a very long leash (Mainini et al. 1993). In California, the presence of dogs along trails correlated with lower detections of raptors and egrets (Abraham 2001). Three previous studies have been performed in Boulder County: Bekoff and Meaney (1997) found very little interaction between dogs and wildlife; Bekoff and Ickes (1999) found that dogs increased prairie dog (*Cynomys ludovicianus*) vigilance and often chased them; and Miller et al. (2001) found mule deer (*Odocoileus hemionus*), vesper sparrows (*Pooecetes gramineus*), western meadowlarks (*Sturnella neglecta*), and American robins (*Turdus migratorius*) showed elevated sensitivity and flushing distances when dogs accompanied hikers, particularly when off-trail.

Methods

Study site selection

The City and County of Boulder, Colorado, have protected over 45,810 ha (113,200 acres) of open space lands, with over 320 km of recreational trails. Most of the lands managed by the City of Boulder Open Space and Mountain Parks (OSMP) allow dogs to be off-leash under "voice and sight control". A portion of trails require leashes, and some prohibit dogs all together. Open spaces managed by Boulder County Parks and Open Space (BCPOS) require dogs to be on-leash on most trails, and prohibit dogs from some trails. In northern Boulder County, BCPOS manages Heil Valley Ranch (1,993 ha)

and Hall Ranch (1,297 ha), both of which prohibit dogs and which were chosen as study sites. For comparison, we then chose two study sites that allow dogs off-leash under "voice and sight control". Based on GIS analysis and the recommendations of OSMP and BCPOS staff, study sites were selected to match the following criteria as closely as possible.

1. Ecological characteristics: Elevation ranging between 1,615 and 2,590 m in Ponderosa pine (*Pinus ponderosa*) and Douglas fir (*Pseudotsuga mensiesii*) forests, with meadows and slopes less than 40° on all aspects.
2. Equivalent visitation: Trails were chosen using best estimates and expert opinions of levels of recreational visitation to each trail. OSMP trails were roughly matched to visitation levels for Heil Valley Ranch (48,890 annual visits in 2003) and Hall Ranch Ranch (74,112 visits) (BCPOS staff). Previous visitation estimates for OSMP trails were ranked on a scale of 1 to 5, with 1 as "very low" and 5 as "very high". Study trails ranked 3 or 4 on this scale (Steve Armstead, pers. comm.). This assumption was tested empirically in the course of the study.

This process resulted in the selection of OSMP land east of the Flatirons along the Mesa Trail corridor from Skunk Canyon south. This area was divided in half to create two sites: Skunk Canyon south to the Big Bluestem trail, including Shanahan Mesa (~1203 ha), and from Big Bluestem south, including Doudy Draw and forested portions of Flatirons Vista (~927 ha). Areas in the study sites that were within 300 m from roads, houses, and other developments were excluded from sampling. Different types of recreationists—hikers, mountain bikers, and equestrians—were assumed to have similar impacts to wildlife. This assumption is based on documentation that these recreational groups cause similar flushing responses for large herbivores in Antelope Island State Park, Utah (Taylor and Knight 2003).

Field methods

At each site, sampling locations were located randomly along trails, and spaced a minimum of 500 m apart. Pellet plots and track plates were performed along transects that ran perpendicular to the trail on one side, away from other trails and steep slopes. Transects consisted of three plots or track plates within three distance categories

perpendicular to the trail: 0-5 m, 50-100 m (randomly selected), and 150-200 m (100 m beyond the 2nd distance). Cameras and scat surveys were performed on-trail only. For all field methods, sampling effort was equivalent across policies.

1. Pellet plots: Activity and habitat utilization of herbivores (deer and rabbits) were measured using pellet-group counts in 100 m^2 circular plots (Bennett et al. 1940, Neff 1968, Collins 1981). One set of plots was cleared summer 2004 and re-checked 12 months later; a second set of plots was cleared early summer 2005 and re-checked three months later.
2. Track plates: Mammal activity was determined by the use of scented track plates, which consisted of a 1 m^2 aluminum plate, sprayed with talc isolated in ethanol, with a scented carnivore lure (Carmen's Pro's Choice and Canine Call, Sterling Trap and Fur, Sterling, Iowa) in a sponge in the middle (Linheart and Knowlton 1975, Zielinski et al. 1996, Belant 2003, Sargeant et al. 2003). While the primary targets of these plates were mid-sized carnivores, track plates were also used in the detection of small mammals (Drennan et al. 1998, Glennon et al. 2002). Plates were checked daily for three rain-free nights. Each day, tracks were photographed and identified using field guides (Halfpenny 2001), plates were cleaned and re-sprayed with talc, and lure was reapplied. The three nights were not considered independent and were therefore collapsed into a single data point. Not all small mammal prints were identifiable to species, so plausible species were listed.
3. Remote-triggered cameras: TrailMaster® brand remote-triggered cameras were used to monitor a variety of mammal species with unambiguous identifications (Kucera and Barrett 1993, Cutler and Swann 1999, but see Rice 1995). In addition to triggering pictures, Trailmaster units also record the timing of "events", which occur when the infrared trigger is broken—usually because a person, dog or animal passes by. In 2004 we used five cameras paired with track plates, both on and off-trail, but with disappointing results. In 2005 we restricted camera placement to recreational trails only and had 10-11 cameras set up at a time at two sites simultaneously. Cameras were set to be active for two weeks (mean=13.5 nights), at a height of .25-.75 m to detect medium-sized carnivores. Vegetation was cleared from the beam path to avoid false events. Camera locations were baited using a mixture of commercial carnivore lures,

and were spaced a minimum of 500 linear m apart. Cameras were revisited every 2-5 days to check on their function, replace film and batteries, and reapply the lure. Due to high numbers of visitors on trails during the day, cameras were only active from approximately 8:00 PM to 8:00 AM. Infrared trigger sensitivity was set between 2 to 4, with a delay of 3 minutes to avoid repeated photos of the same animal. Cameras were hidden using camouflage materials, and were cable-locked to trees with small signs explaining their purpose.

4. On-trail scat surveys: Because circular pellet plots were not detecting enough carnivore scat, and as we frequently observed carnivore scat along trails, we initiated on-trail scat surveys. Scat surveys were conducted continuously from July 2004 through October 2005 and were conducted on a sub-set of study trails. Trails were walked and scat was identified using field guides (Halfpenny 2001) and cleared from the trail, in two-week intervals (mean=17 days). Pictures and samples were taken for further analysis. To test the accuracy of the scat identifications, the DNA from 50 scat samples was identified to species (Paxinos et al. 1997, Mills et al. 2000).
5. Prairie dog study: We identified seven recreational trails in Boulder County that occur adjacent to prairie dog colonies, each with a relatively "unbounded" geography that did not limit the movement of prairie dogs or the location of their burrows (Johnson and Collinge 2004). Three of these trails were in areas that did not allow dogs, and four were in areas that allow dogs off-leash under "voice and sight control". We selected segments of these trails where prairie dog burrows existed continuously from the trail up to at least 200 m from the trail on one side. We identified active burrows by observation of prairie dog activity, including fresh scat, evidence of digging, tracks, clear burrow openings, and prairie dogs themselves (Powell et al. 1994). With a laser rangefinder, we measured the perpendicular distance from the trail to each active burrow within this trail segment, up to 200 m from the trail.

Statistical analyses

We established $\alpha = 0.1$ *a priori* for all analyses to minimize the possibility of Type II errors (Holling and Allen 2002). All effects and interactions included in models were

selected *a priori* as relevant to the biology of the response organisms. In all cases we eliminated effects to include only those significant at $\alpha = 0.1$.

1. Pellet plots: Data were converted to a density of pellet piles per hectare sampled, and were square-root transformed to normalize variance. For both rabbits and mule deer, a mixed model analysis of covariance (ANCOVA) was performed using PROC MIXED in Statistical Analysis Software (SAS, 2005). The response was modeled to include the fixed effects of dog policy, site, date, and distance from trail (three distance categories), a continuous covariate of an estimation of hourly visitation to that segment of trail, a random effect of transect location, and relevant interactions between these effects. When the overall F-test was significant for the effect of distance categories or the interaction of distance categories and dog policy, pairwise comparisons between these categories were made with the least-significant-difference method (Ott & Longnecker 2001).
2. Track plates: The three nights of track plate data were combined into one data point with whole number counts of each species detected; species not detected were counted as "zeros" in the dataset. These count data were then converted to an index of detection frequency (I) by dividing the count of detections per species (X) by the number of trap nights (n): $I=X/n$. This dataset was then analyzed using a mixed model ANCOVA for binomial data using PROC GLIMMIX (SAS, 2005). The model effects and their associated F-tests were the same as in the pellet plot analysis described above. Response variables included domestic dogs and a combination of small mammals including squirrels, rabbits, chipmunks, mice and voles.

3a. Remote-triggered camera event data: Trailmaster events are non-specific recordings of the breaking of the infrared beam, recorded as number of events per hour. Events were presumed to bear a consistent relationship with visitation along a trail, and the majority of events were assumed to be human and pet trail visitors. Trailmaster cameras frequently malfunctioned (maxed out events, transmitter out of alignment, batteries died, etc.), so the event dataset had variable gaps throughout the two weeks they were active at each location. We did not adjust for double counts (when single visitors passed monitors more than once) or for multiple counts (when visitors passed more than one monitor on a single outing). Because visitation peaked on weekends, we

normalized the dataset to give equal weight to weekday and weekend visitation using the following adjustment: 1) all incomplete days were dropped from the dataset; 2) separate hourly visitation averages were computed for weekdays and weekends; 3) data were recombined to normalize weekday and weekend hourly visitation using the formula: *Visitation (normalized) = (5/7)*weekday visitation + (2/7)*weekend visitation.* Normalized hourly visitation data for each trail segment was combined by dog policy and by site. Tests of equivalent visitation across dog policies were conducted using a Sattherwaite t-test, which allows for unequal variance between the samples (PROC TTEST in SAS).

Such tests of equivalent visitation refer to humans, not dogs, but visitors to OSMP trails have been estimated to be accompanied by at least one dog 30% of the time (Mertz 2002). Thus, we expected that a proportion of events were caused by dogs, additive to the events triggered by humans. To test only visitation rates by humans across policies, we adjusted the event data for OSMP sites by assuming that 30% of visitors were indeed accompanied by dogs, and so the events should equal 130% of human-triggered events. Thus, the proportion of events excluding dogs to total events was 100% / 130% = 0.769; we multiplied this number by all OSMP visitation estimates to gain an adjusted hourly visitation estimate, and re-tested the equivalence of visitation using a t-test (PROC TTEST in SAS).

3b. Remote triggered camera photo data: Similar to the track plate data, an index (I) of activity for photos was calculated by dividing the number of photos (X) of any species by the number of nights (n) the Trailmaster cameras were active: $I=X/n$. This dataset was square-root transformed to normalize the variance, then analyzed using a mixed model ANCOVA with the fixed effects of dog policy and site, the continuous covariate of visitation, and the random effect of transect location (PROC MIXED in SAS). When the overall F-test for site was significant, pairwise comparisons between sites were performed. Only data from 2005 was used in this analysis. Also, we hypothesized that dog activity was correlated with average visitation levels, so we tested this by fitting a linear regression between these variables (PROC REG in SAS).

4. On-trail scat surveys: For each survey, trails were broken into 1-km segments, and data were converted to a density of scats per km, for each species detected. Data were

square-root transformed to stabilize the variance. DNA results indicated variable precision with scat identification, so all native carnivore scat was combined, excluding black bears, which were not confused with other scats. Data for each trail segment were averaged per month, and these data were then modeled using a mixed model repeated-effects analysis of variance (ANOVA), with interactions. We expected that adjacent months and adjacent kilometer segments would be correlated, so we considered a first-order autoregression matrix (AR-1) on both these variables to model our assumption that the data was both temporally and spatially autocorrelated (Ott and Longnecker 2001). We tested the appropriateness of the AR(1) covariance structure with asymptotic Wald Z-tests on the covariance parameter estimates within each model and eliminated the autoregressive covariance structure when it did not have significant influence on the model (SAS 2004). We initially considered the fixed effects of dog policy, site, month, the presence of a trailhead, and relevant 2- and 3-way interactions of these effects, plus kilometer segment location as a random effect and month as a repeated measures variable, and dropped insignificant effects. Visitation estimates were not available for these trail segments. The final model was used for overall F-tests on each effect.

5. Prairie dog burrow location: Distance from each prairie dog burrow to the trail was pooled by dog policies. To normalize for the variable widths of the trail segments running through the prairie dog colonies that were measured, the raw number of burrows extending fixed distances away from the trail were divided by the width of the trail segment to create a density of burrows per meter of trail: *density = # burrows / meters of trail.* This density was calculated for the complete dataset, extending up to 200 m from the trail, and for truncations of the dataset focusing progressively closer to the trail: 100 m, 50 m, 25 m, and 10 m. Within each set distance from the trail, we compared the mean burrow densities across dog policies using Sattherwaite t-tests to deal with unequal variance (PROC TTEST in SAS).

Results

Visitor use

A t-test on all normalized event data indicated overall visitation between policies to be significantly higher on OSMP lands where dogs are allowed (df=55.8, t=2.13, p=0.0375). However, a second t-test on adjusted visitation data (presuming 30% accompaniment by dogs) indicated that overall visitation did not differ between policies (df=60, t=0.57, p=0.5738), thus meeting the assumption of equal visitor use across policies. Despite meeting this assumption, visitation estimates for individual trail segments were used as covariates in all analyses except on-trail scat surveys and prairie dog burrow densities.

Pellet plots

Pellet plot data indicated that the activity of mule deer and rabbits were both lower along trails in areas that allow dogs and that the strength of this effect was influenced by the distance from the trails. For both 12-month and 3-month summer pellet plots, dog policy and distance from the trails were significant predictors of deer activity (Fig. 1). In areas that allow dogs, deer were significantly less active within 0-5 m of trails than 50-100 m of trails (year: F_{44}=-3.28, p=0.002; summer: F_{28}=-2.25 p=0.0328), and within 50-100 m than 150-200 m from trails (year: F_{44}=-3.97, p=0.0003; summer: F_{28}=-4.07 p=0.0003). However, even in areas that prohibit dogs, deer activity was lower within 5 m of trails than 50-100 m from trails (year: F_{44}=-5.38, p<0.0001; summer: F_{28}=-3.45 p=0.0018), but deer activity did not differ between 50-100 m and 150-200 m from trails (year: F_{44}=1.49, p=0.1435; summer: F_{28}=-0.22 p=0.8247). Comparing between dog policies, where dogs are allowed deer were significantly less active at two distances from the trails: within 5 m (year: F_{44}=1.89, p=0.0657; summer: F_{28}=1.73 p=0.0938) and within 50-100 m (year: F_{44}=3.56, p=0.0009; summer: F_{28}=2.93 p=0.0067). Within 150-200 m of trails deer activity did not differ by dog policy (year: F_{44}=-0.80, p=0.4268; summer: F_{28}=-0.90 p=0.3736).

Rabbit activity was also significantly lower along trails in areas that allow dogs, but trends varied between the one-year and three-month plots (Fig. 2). For the one year plots, dog policy (F_{22}=4.93, p=0.0369) and distance from trail (F_{44}=2.89, p=0.0665) were

significant predictors of rabbit activity, but over the summer only dog policy was significant (F_{12}=9.56, p=0.0093). In areas that allow dogs, rabbit activity was similarly low within 5 m of trails and within 50-100 m of trails (year: F_{44}=-0.89, p=0.3779) but was significantly higher at 150-200 m of trails (year: F_{44}=-2.10, p=0.0419).

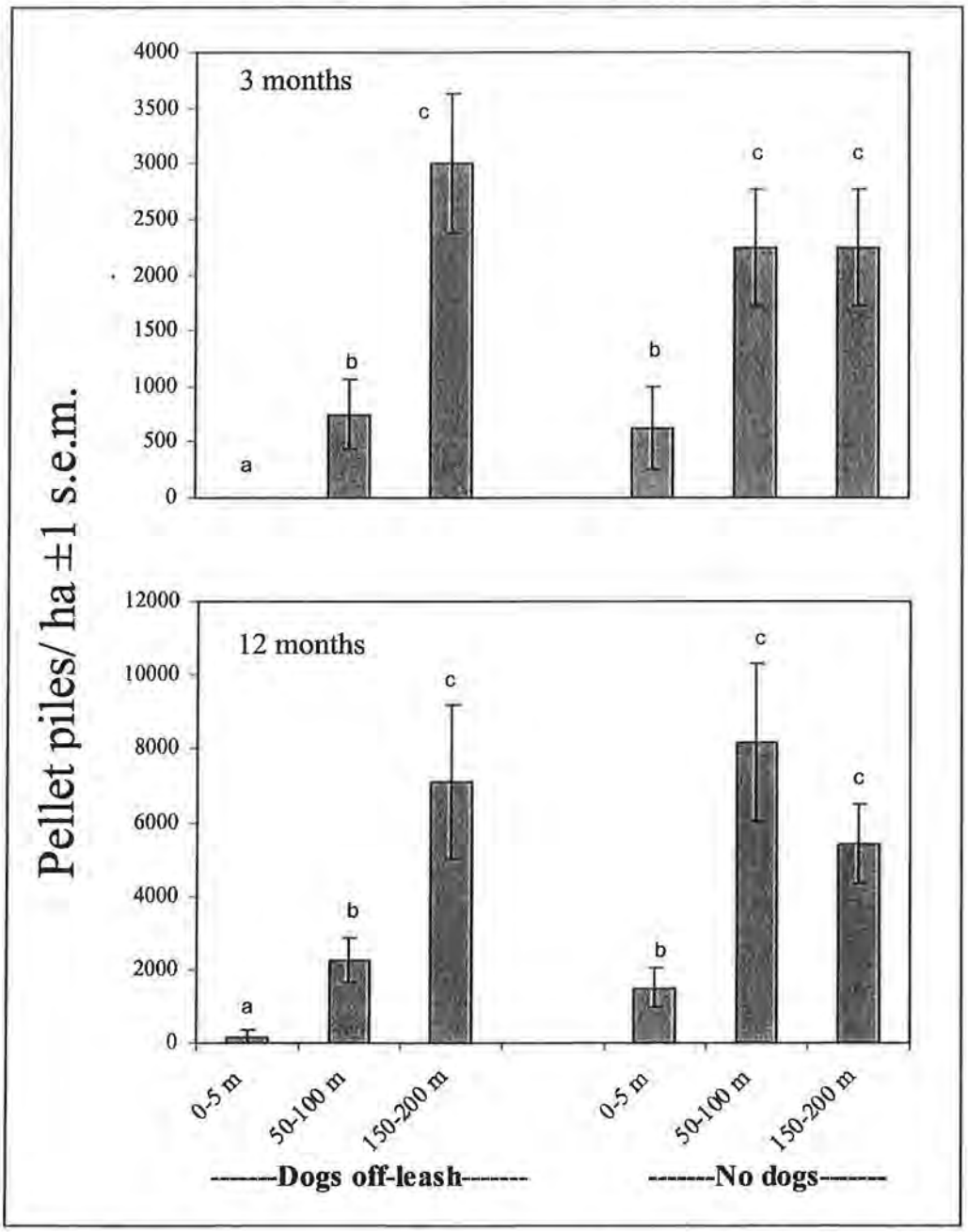

Fig. 1. 12-month and 3-month deer pellet densities by dog policy and distance from trail. Different letters above columns indicate significant differences (p<0.1) between 1) adjacent distance categories within policies, and 2) the same distance category between policies, based on a square root transformation of the data presented.

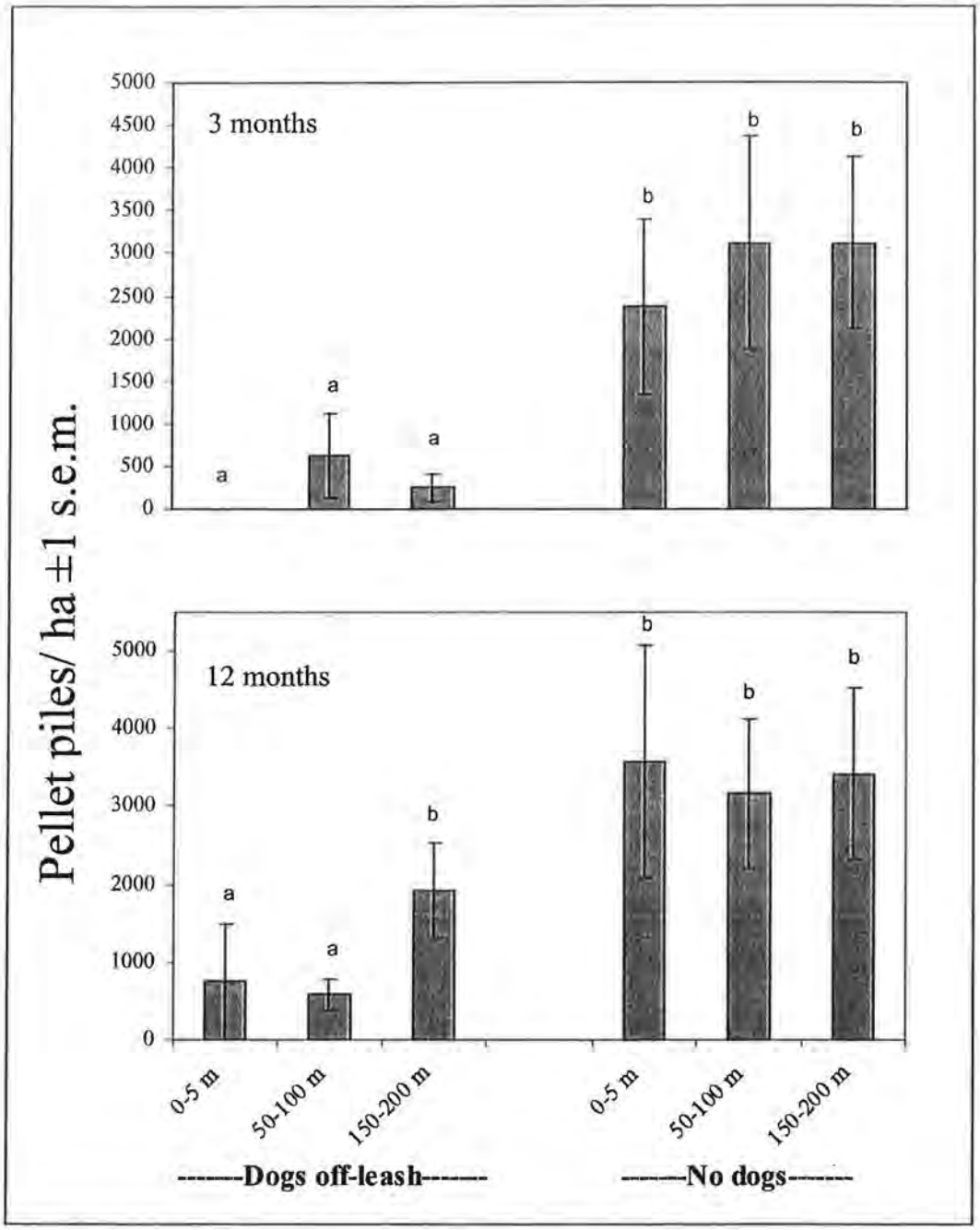

Fig. 2. 12-month and 3-month rabbit pellet densities by dog policy and distance from trail. Different letters above columns indicate significant differences ($p<0.1$) between 1) adjacent distance categories within policies, and 2) the same distance category between policies, based on a square root transformation of the data presented.

In areas that prohibit dogs, distance from the trail did not influence rabbit activity. Comparing across dog policies, areas that allow dogs had lower rabbit activity over the course of a year at two distance categories from trails: within 5 m (year: F_{44}=2.49, p=0.0168), and within 50-100 m of trails (year: F_{44}=2.32, p=0.0246), but not within 150-

200 m of trails (year: F_{44}=0.73, p=0.4697). This trend was not present with the summer plots.

Track plates

Track plate data indicated that in areas that allow dogs off-leash, dogs traveled up to 85 m from trails, but the vast majority of dog detections were within 5 m of trails. Small mammal tracks were not identifiable to all species, but included rabbits (*Sylvilagus spp.*), squirrels (*Sciurus spp.*), chipmunks (*Eutamias spp.*), ground squirrels (*Spermophilus spp.*), mice (*Peromyscus spp., Reithrodontomys spp., Onychomys spp., Zapus spp., Mus spp.*), voles (*Clethrionomys spp., Phenacomys spp., Microtus spp.*), and rats (*Rattus spp., Neotoma spp.*) (Fitzgerald et al. 1994). Together, the activity of these species was inversely correlated with the presence of dogs (Fig. 3). Within 5 m of trails, small mammal activity was significantly lower in areas that allowed dogs than in areas that prohibit dogs (T_{94}=3.36, p=0.0011). Within areas that allow dogs, small mammals were less active within 5 m of trails than 50 m or further from trails (T_{94}=-3.63, p=0.0005).

Remote-triggered cameras

Dog policy was a significant predictor of activity levels for a variety of species, including dogs, red foxes (*Vulpes vulpes*), bobcats (*Lynx rufus*), and all native carnivores combined (Fig. 4). Other carnivores detected included grey foxes (*Urocyon cinereoargenteus*), black bears (*Ursus americanus*), mountain lions (*Felis concolor*), striped skunks (*Mephitis mephitis*), coyotes (*Canis latrans*) and raccoons (*Procyon locor*). As expected, dogs were photographed significantly more on trails that allow dogs than trails that prohibit dogs ($F_{1,57}$ =77.19, p<0.0001). Dog activity was also somewhat correlated with visitation (R^2=0.218, $F_{1,29}$=1.82, p=0.008). On trails that allow dogs, activity was also higher for native carnivores ($F_{1,60}$ =16.09, p=0.0002), including native canids ($F_{1,57}$ =18.06, p<0.001) and especially red foxes ($F_{1,57}$ =13.97, p=0.0004). Red foxes constituted 49% of all native carnivore photos; 58% when excluding black bears. Dog activity was inversely correlated with bobcat activity ($F_{1,57}$ =5.89, p=0.0184). Unlike the results from our pellet data, mule deer activity on trails was not different between policies ($F_{1,60}$=0.16, p=0.6929).

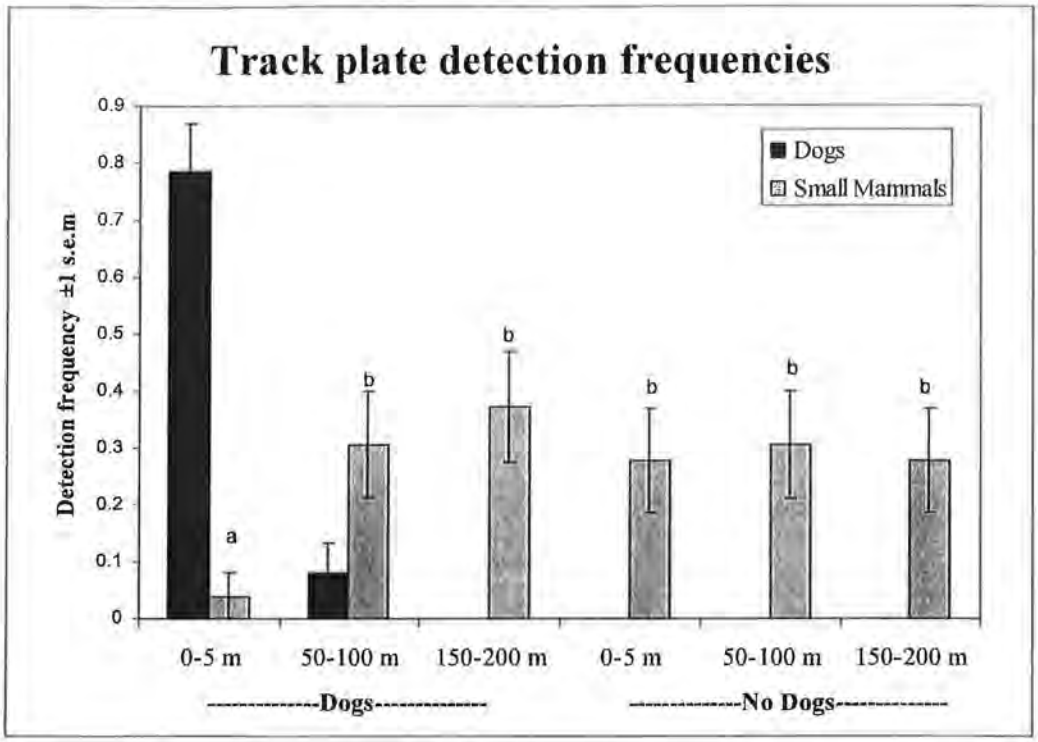

Fig. 3. Track plate detection frequencies for dogs and small mammals. Different letters above columns indicate significant differences between distance categories and policies for small mammals ($p<0.1$) based on a square root transformation of the data presented.

On-trail scat surveys

On-trail scat surveys also showed dog policy to be a strong predictor of dog activity ($F_{1,34.5}=61.32$, $p<0.0001$) (Fig. 5). Similar to the photo data, these trails also had higher levels of native carnivore activity ($F_{1,38.2}=19.01$, $p<0.0001$). Dog policy was not the sole significant predictor of scat density, however. For both dogs and native carnivores, seasonal variation was considerable, and the month of the survey influenced scat density (dogs: $F_{11,230}=2.18$, $p=0.0161$; carnivores: $F_{11,231}=3.17$, $p=0.0005$), as did the interaction of month with dog policy (dogs: $F_{10,215}=3.85$, $p<0.0001$; carnivores: $F_{10,209}=3.68$, $p=0.0001$). The presence of a trailhead within a kilometer segment increased dog activity ($F_{1,24.5}=15.12$, $p=0.0004$) and decreased carnivore activity ($F_{1,42.2}=5.95$, $p<0.019$) (Fig. 6). For dogs, the strength of the trailhead effect depended on dog policy ($F_{1,34.5}=14.26$, $p=0.0006$) and also on the month ($F_{21,207}=1.86$, $p=0.0149$). The lower density of carnivore scat near trailheads was also dependent upon month ($F_{11,231}=1.77$, $p=0.0603$). For

carnivores, significant variation in activity levels also existed between the four study sites ($F_{2, 27.9}$=9.51, p=0.0004).

For both dogs and native carnivores, modeling the temporal autocorrelation between adjacent months using an AR(1) autocovariance structure significantly reduced the variance in the final model (dogs: Z= 3.03, P=0.0024; carnivores: Z= -1.65, P=0.0993).

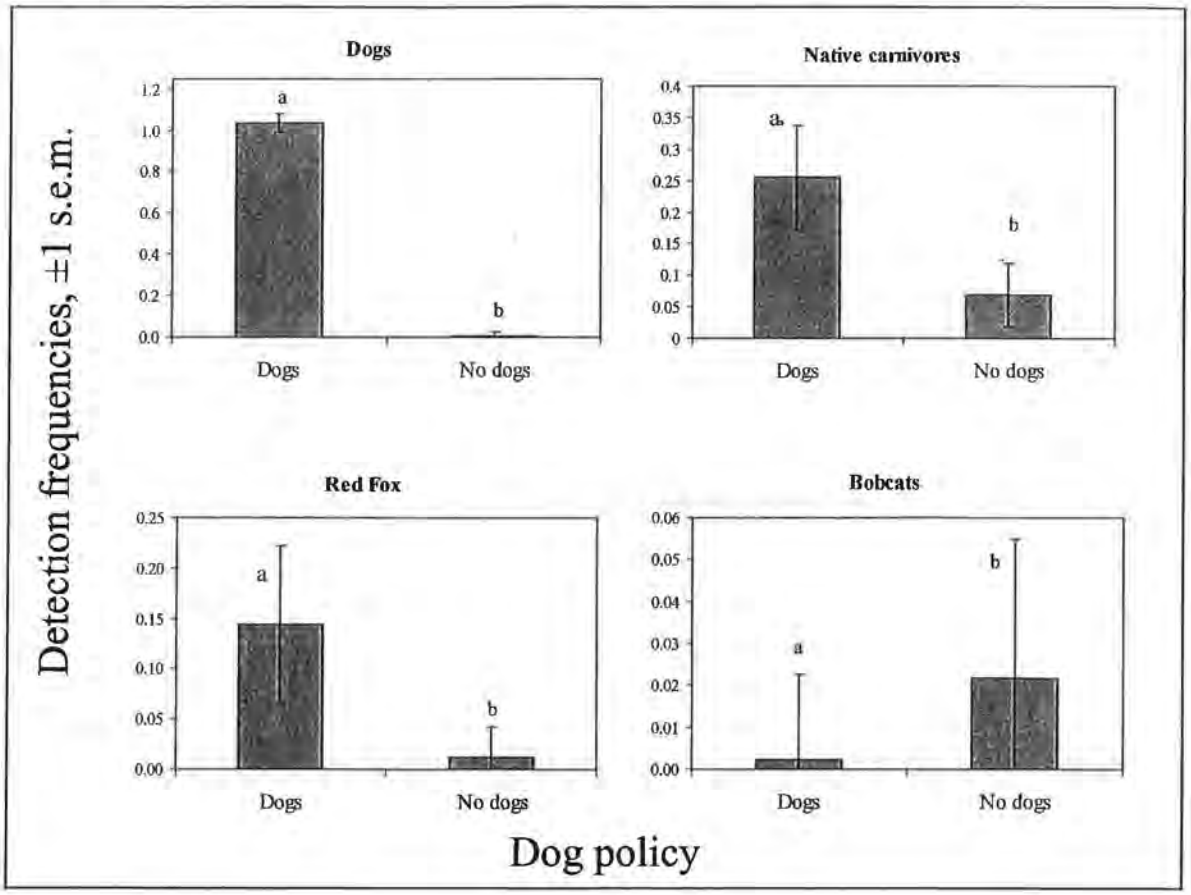

Fig. 4. Photo detection frequencies (photos / night) of four groups of animals by dog policy. Different letters above columns indicate significant differences (p<0.1) based on a square root transformation of the data presented.

Prairie dog burrow densities

Dog policy did not significantly predict prairie dog burrow density within 200 m ($t_{2.3}$=1.14, p=0.3574), 100 m ($t_{3.65}$=1.07, p=0.3487), or 50 m of the trail ($t_{3.17}$ =1.72, p=0.1796). However, in areas where dogs are prohibited there were significantly higher

densities of prairie dog burrows within 25 m ($t_{4.59}$=3.78, p=0.0151) and 10 m of trails ($t_{4.65}$=3.86, p=0.0136).

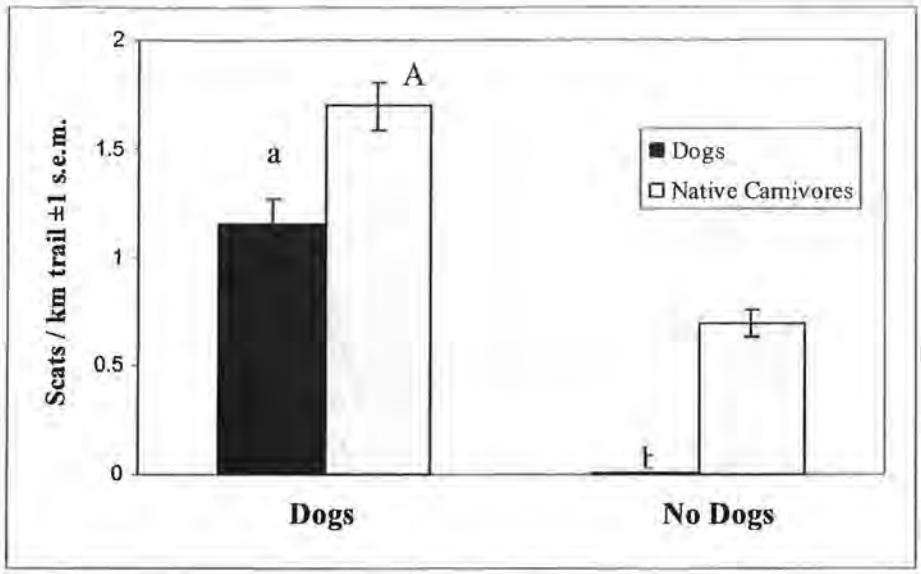

Fig. 5. On-trail scat densities by dog policy for dogs and combined native carnivores, including coyotes, red foxes, grey foxes, bobcats and mountain lions. Different letters above columns indicate significant differences (p<0.1) based on a square root transformation of the data presented. Capital letters represent statistical comparisons for native carnivores, and lower case letters refer to comparisons for dogs.

Discussion

The presence and spatial use patterns of dogs in open spaces of Boulder County correlated with altered patterns of wildlife activity. As expected, dog activity was focused along recreational trails, but was not restricted to the trail itself. In areas both with and without dogs, the density of mule deer pellets indicated that deer were less active close to trails. In areas that prohibit dogs, deer activity was decreased within 50 m of trails; this represents the baseline recreational disturbance on mule deer by hikers, equestrians and mountain bikers. Where dogs are allowed the disturbance was greater: deer activity was decreased within 100 m of trails. Photo data indicated that trails are not boundaries for deer movement, as frequencies of deer photos on trails did not differ between dog policies. But pellet densities are a more sensitive measure of deer activity and habitat utilization because they indicate areas where deer are able to pause, rest, and bed down—areas where deer are not disturbed, but relaxed.

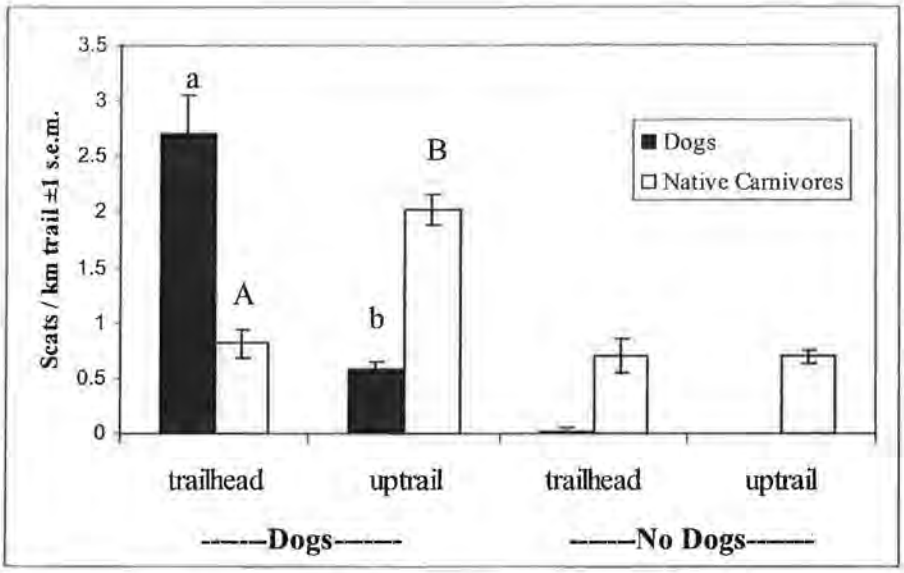

Fig. 6. On-trail scat densities by dog policy, within 1 km of trailheads or uptrail, for dogs and combined native carnivores, including coyotes, red foxes, grey foxes, bobcats and mountain lions. Different letters above columns indicate significant differences ($p<0.1$) based on a square root transformation of the data presented. Capital letters represent statistical comparisons for native carnivores, and lower case letters refer to comparisons for dogs. No trailhead effect was found in areas that prohibit dogs.

These findings are consistent with the behavioral response of mule deer to dogs. Miller et al. (1999), also in Boulder County, observed that mule deer were more sensitive and flushed at greater distances from pedestrians when they were accompanied by a dog, and that the behavioral response of deer was greatest when pedestrians with dogs were off-trail. Dogs off-leash frequently travel off-trail—up to 85 m in this study. Wildlife that are sensitive to recreational disturbance are generally most sensitive to unpredictable spatial patterns of disturbance (MacArthur et al. 1982, Knight and Cole 1995), whereas predictable spatial activities, such as activity restricted to trails, allows wildlife to habituate to the disturbance (Whittaker and Knight 1999). The spatial behavior of off-leash dogs is unpredictable, and when dogs wander off-trail they are likely to elicit flushing responses from deer, even if they do not give chase (Miller et al. 2001). Decreased detections of deer pellets within 100 m of trails in areas that allow dogs indicate these behavioral responses translate to altered patterns of habitat utilization, and make the trail corridor less suitable for mule deer. The same is true for small mammals including squirrels, rabbits, chipmunks

and mice, though these species' activity resumes normal levels within 50 m from trails in areas that allow dogs.

Similar altered patterns of habitat utilization were found in prairie dog colonies adjacent to recreational trails. Bekoff and Ickes (1999) demonstrated prairie dogs behave more vigilantly in the presence of dogs, even when they are not chased. Our results indicate that this behavioral response can translate into altered patterns of burrow placement, which is less frequent within 25 m of trails in areas that allow dogs than in areas that prohibit dogs.

On-trail scat surveys and remote-triggered photos indicated several relationships between the activity of dogs and carnivores. Along trails that allow dogs, native carnivore activity—predominantly red foxes—was higher than in areas that prohibit dogs. Dog scat densities were highest and native carnivore scats were lowest within a kilometer of trailheads. The opposite was true up-trail, where dog scat densities were lower, and native carnivore scat densities, as well as photo detection frequencies, were higher. Trailheads did not influence carnivore activity where dogs were prohibited. Several observations may explain these trends. Most dogs defecate very soon after arriving at a trail, and many visitors do not walk dogs much beyond the trailhead. However, the dogs that are allowed to continue along the course of the trail continue to urinate and scent-mark areas previously marked by other dogs and carnivores, creating what may seem to native carnivores to be a dog territory. Foxes and other carnivores, especially canids, may be attracted to these areas to patrol, maintain, and possibly defend their territories (Henry 1977). We may speculate that up-trail, elevated detections of red foxes (and other carnivores) where dogs are allowed hints at increased vigilance and territorial maintenance along trails. As this trend does not hold within a kilometer of trailheads, perhaps this elevated carnivore response only occurs up to a certain threshold of dog and human activity that is exceeded near trailheads, where dog scat is abundant and carnivore scat is rare. However, these speculations cannot be confirmed through our methods or through any index of activity (Anderson 2001).

Very low frequencies of bobcat photos on trails in areas that allow dogs indicate that bobcats may also be sensitive to the presence of dogs, and may avoid areas they frequent. Bobcats are secretive and elusive from humans, though they are considered

resilient to broad-scale land use change (Woolf and Hubert 1998). In Colorado, coyotes are an important natural predator of bobcats (Fitzgerald et al. 1994). Bobcats may perceive dogs as canid threats similar to coyotes, so it is possible that the presence of dogs may deter them from otherwise suitable habitat.

Several alternative explanations of the data exist, and warrant further study. First, this study was designed to analyze spatial patterns of wildlife activity, but the influence of recreationists, including dogs, could lead instead to alterations in temporal activity patterns. Such is the case in southern California, where high levels of recreational visitation correlate with altered temporal patterns of wildlife activity (George and Crooks, *in press*). Thus, the spatial activity patterns we studied may not illustrate the complete picture of how wildlife manages to co-exist with high levels of human recreation and dogs in a limited area.

Second, landscape-scale geographic differences exist between our no-dog sites (BCPOS in northern Boulder County) and dog sites (OSMP in southern Boulder County). OSMP sites are in closer proximity to an urban area (Boulder), which could allow subsidization of human-commensal species such as red foxes and black bears, both of which were detected more frequently on these sites. Also, the location of trails within the landscape may differ. In particular, the trails on Heil Valley Ranch (no dogs) are limited to one plateau with little habitat diversity and lower levels of wildlife activity than other parts of the same open space (Given 2001).

Conclusion

We studied the indirect interactions of dogs with wildlife and documented that trails in areas that allow dogs have a wider area of influence on mule deer and small mammals, including prairie dogs, rabbits, squirrels and mice. This area of influence surrounding trails is potentially unsuitable habitat for these species. In these areas, visitors are less likely to view these wildlife species. Carnivores, such as red foxes and bobcats, may also alter their behavior in these areas.

Management Recommendations

Policies regulating types of recreational use on trails should be considered within a regional context, including trails managed by Boulder County Parks and Open Space, the City of Boulder Open Space and Mountain Parks, the Arapahoe-Roosevelt National Forest, Rocky Mountain National Park, Eldorado Canyon State Park, and other public and private lands. The types of recreational uses allowed on these trails influence the rates of recreational visitation and their associated ecological impacts. Trails that allow dogs or mountain bikes lead to higher recreational use, and these types of recreation may not always be entirely compatible (BCPOS 2004). Within such a regional context, trails that are kept dog-free could protect against the demonstrated ecological impacts that dogs have on wildlife communities and could facilitate wildlife viewing opportunities for trail users.

Recommendations for further research

To further explore the effects of dogs on wildlife communities, we recommend before-after control-impact studies with any new trails that are created. Particularly strong inference could be gained through a crossover study design where trail policies are switched temporarily from dogs to no-dogs, and vice-versa, with target species monitored as desired. Also, studies that can estimate population sizes, such as through a mark-recapture study using DNA or photos, would allow determination of relative detection frequency on trails for individual animals. Then it would be possible to know if carnivores spend relatively more time on trails more when dogs are present, which would indicate elevated investment towards territorial maintenance and defense.

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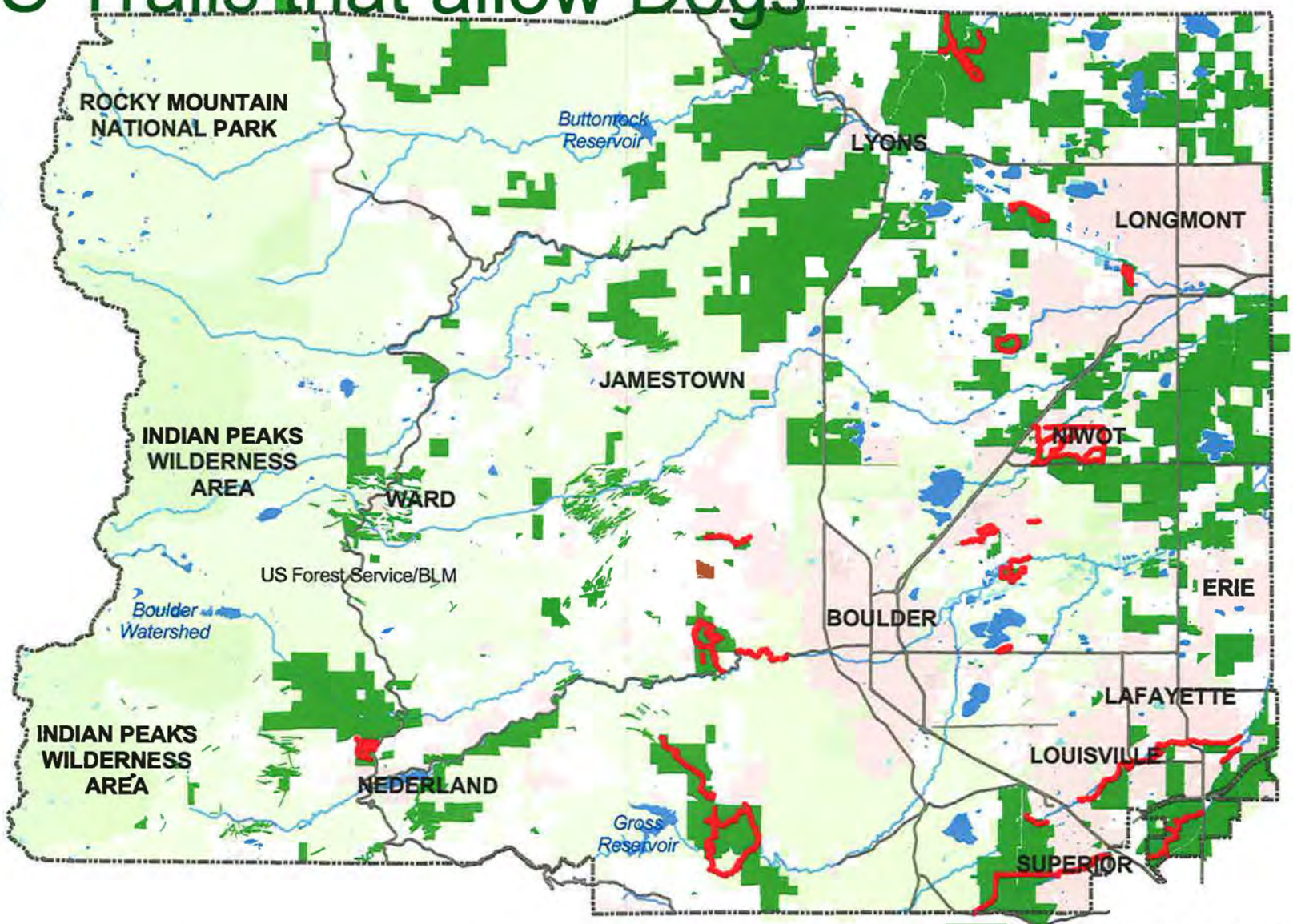
POS Trails that allow Dogs



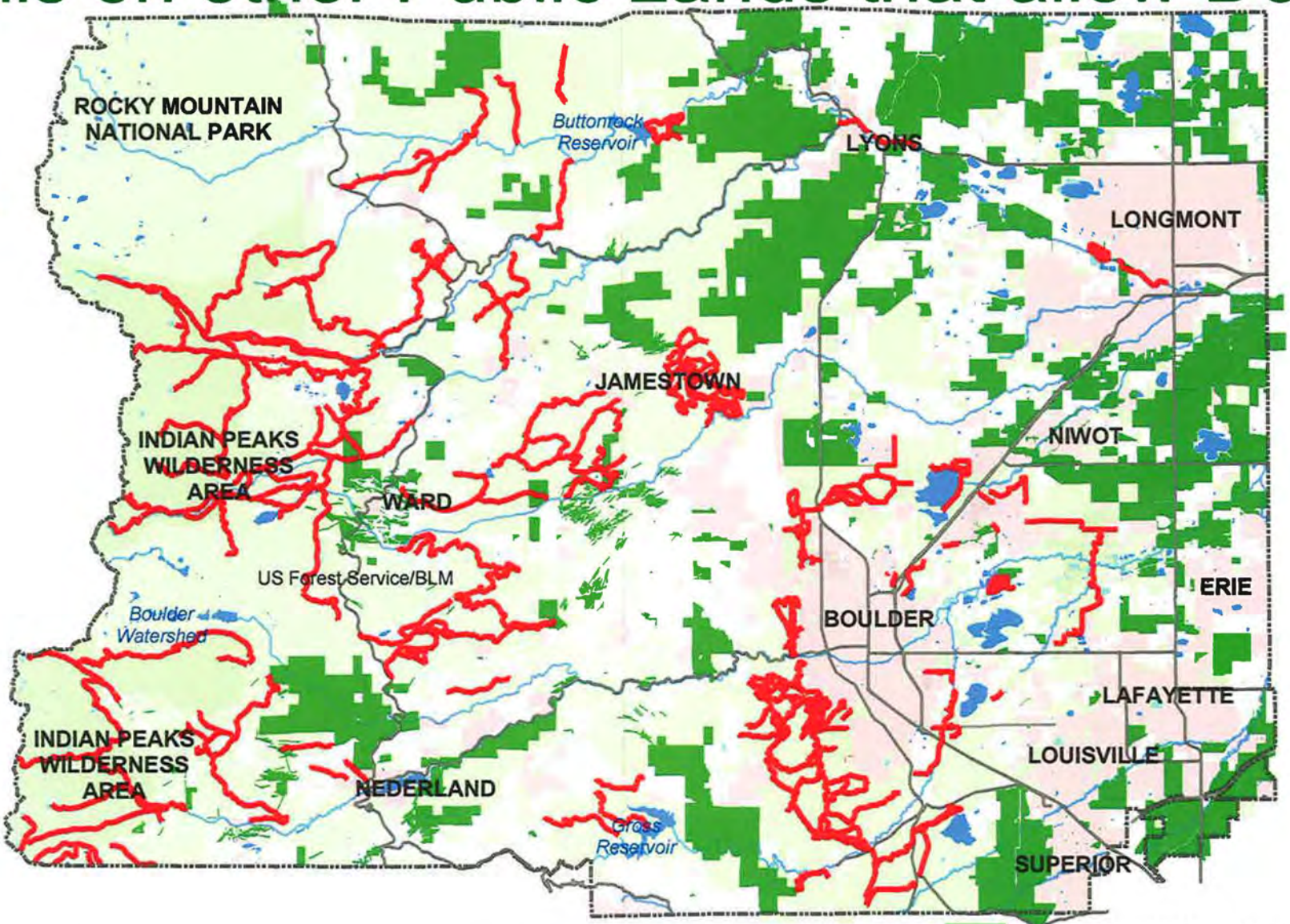
Boulder County Open Space

Other Open Space/Public Lands

Cities/Towns/Subdivisions

POS Trails that do allow Dogs

Trails on other Public Lands that allow Dogs



Boulder County Open Space

Other Open Space/Public Lands

Cities/Towns/Subdivisions

Other Trails that do allow Dogs

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STATE OF COLORADO

Bill Owens, Governor
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WILDLIFE
AN EQUAL OPPORTUNITY EMPLOYER

Bruce McCloskey, Director
6060 Broadway
Denver, Colorado 80216
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For Wildlife-
For People

January 11, 2006

Dave Hoerath
Wildlife Specialist
Boulder County Parks and Open Space Resource Management Division
5201 St. Vrain Road
Longmont, CO 80503

RE: Dog Policy on Heil Valley Ranch and Hall Ranch Open Space

Dear Mr. Hoerath:

The Colorado Division of Wildlife (CDOW) appreciates the opportunity to comment on issues regarding trail use on Heil Valley Ranch and Hall Ranch Open Space. District Wildlife Manager Windi Padia has made numerous site visits to both properties.

Both Boulder County Open Space properties provide many acres of habitat for wildlife including deer, elk, turkeys, raptors, small mammals, bald eagles, golden eagles, black bears, puma, coyotes, foxes, songbirds, and other wildlife. The properties also provide trail users the opportunity to view wildlife which enhances the recreation experience.

To that end, we recommend maintaining the no-dog policy on both Heil Valley Ranch and on Hall Ranch. Currently, a person hiking on Hall Ranch in the early mornings and late afternoons has the opportunity to view mule deer herds. The presence of dogs would diminish this opportunity.

A little recognized consequence of human recreation in wildlife habitats is the effect domestic dogs have on wildlife, even in the company of their owners. Most domestic dogs still retain instincts to hunt and/or chase other animals. Even if dogs are controlled and not allowed to chase wildlife, their very presence has been shown to be disruptive to many wildlife species. Especially during winter, harassment by dogs results in excessive energy expenditures by wildlife. During spring and summer, pregnant wildlife and newborns can be particularly vulnerable to harassment or attacks by domestic dogs. Dogs are noted for their "incidental" predation upon birds and small mammals during all seasons. Domestic dogs can potentially introduce diseases (distemper, parvovirus, and rabies) and transport parasites into wildlife habitats. Research has shown that flight distances of mule deer from domestic dogs on leash are far greater than flight distances from pedestrians alone (Miller et.al, 2001). While impacts of domestic dogs are most notable for their effects on individual animals, the cumulative effects from dogs may have important implications for wildlife populations.

DEPARTMENT OF NATURAL RESOURCES, Russell George, Executive Director
WILDLIFE COMMISSION, Jeffrey Crawford, Chair • Tom Burke, Vice Chair • Ken Torres, Secretary
Members Bernard Black • Rick Enstrom • Philip James • Claire O'Neal • Brad Phelps • Robert Shoemaker

If you have any questions please contact DWM Windi Padia at 303-906-3643. Again, thank you for this opportunity to comment.

Sincerely,

for Mark Leslie Area Wildlife Manager

Scott Hoover
Regional Wildlife Manager
CDOW