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Recreation and large mammal activity in an urban nature reserve

Shalene L. George[a,1], *Kevin R. Crooks*[b,*]

[a]*Department of Wildlife Ecology, University of Wisconsin, Madison, WI 53706, USA*
[b]*Department of Fish, Wildlife, and Conservation Biology, Colorado State University, 115 Wagar, Fort Collins, CO 80523, USA*

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ABSTRACT

Human recreation has immediate and long-term impacts on wildlife, and exposure to recreational activities might be particularly high in urban systems. We investigated the relationship between human recreation and the spatial and temporal activity patterns of large mammals in an urban nature reserve. Data from remotely triggered infra-red cameras (1999–2001) were used to assess activity for bobcat, coyote, mule deer, humans, and domestic dogs along paths in the Nature Reserve of Orange County (NROC), California. Forty-nine camera sites established across the NROC yielded 16,722 images of humans, dogs, and our three target large mammal species during 4232 observation nights. Results suggest that bobcats, and to a lesser degree coyotes, exhibited both spatial and temporal displacement in response to human recreation. Bobcats were not only detected less frequently along trails with higher human activity, but also appeared to shift their daily activity patterns to become more nocturnal in high human use areas; negative associations between bobcat and human activity were particularly evident for bikers, hikers, and domestic dogs. In general, both bobcats and coyotes displayed a relatively wide range of activity levels at sites with low human use, but a lower and markedly restricted range of activity at those sites with the highest levels of recreation. Although we did not find a clear and consistent pattern of avoidance of human recreation by deer, the probability of detecting deer during the day was lower with increasing levels of human recreation. Future studies that experimentally investigate the impacts of recreationists on wildlife, as well as relate behavioral responses to survival and reproduction, will allow further insight of the effects of urban recreation on large mammal populations.

1. Introduction

The impacts of human disturbance on animal behavior and conservation have received growing attention (Clemmons and Buchholz, 1997; Caro, 1998; Gosling and Sutherland, 2000; Frid and Dill, 2002; Kerley et al., 2002; Festa-Bianchet and Apollonio, 2003). One such disturbance, human recreation, may lead to an array of immediate and long-term impacts on the activity, reproduction, and survival of wildlife (Knight and Cole, 1991; Knight and Gutzwiller, 1995; Whittaker and Knight, 1998). Indeed, outdoor recreation is a primary cause of the decline of threatened and endangered species in the United States (Losos et al., 1995; Czech et al., 2000; Taylor and Knight, 2003). Studies have suggested that human recreational activities can impact a wide variety of species, including marine mammals (Allen et al., 1984),

* *Corresponding author:* Tel.: +1 970 491 7936.
E-mail address: kcrooks@cnr.colostate.edu (K.R. Crooks).
[1] Present address: Wildlife Management Program, Nez Perce Tribe, 260 Phinney Avenue, Lapwai, ID 83540, USA.
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rodents (Mainini et al., 1993; Magle et al., 2005), birds (Yalden and Yalden, 1990; Miller et al., 1998; Stalmaster and Kaiser, 1998; Fernández-Juricic et al., 2005), herpetiles (Hecnar and M'Closkey, 1998; Lacy and Martins, 2003; Rodríquez-Prieto and Fernández-Juricic, 2005), and coral (Zakai and Chadwick-Furman, 2002).

Mammalian carnivores, given their low population densities, large area requirements, and historical and current persecution, may be especially sensitive to anthropogenic disturbances (Terborgh, 1974; Pimm et al., 1988; Breitenmoser, 1998; Woodroffe and Ginsberg, 1998; Woodroffe, 2000; Crooks, 2002; Gittleman et al., 2001; Ray et al., 2005), and prior studies have suggested human recreation can alter carnivore behavior and distribution (e.g. Aaris-Sorensen, 1987; Olson et al., 1997; White et al., 1999; Nevin and Gilbert, 2005a,b). Likewise, human recreation can also disturb ungulates, initiating alert and flush responses and potentially resulting in decreased foraging or reproduction, increased energetic costs or stress, and avoidance of recreational areas (Eckstein et al., 1979; MacArthur et al., 1982; Freddy et al., 1986; Yarmoloy et al., 1988; Papouchis et al., 2001; Miller et al., 2001; Taylor and Knight, 2003). Although most studies of recreational impacts on large mammal activity have occurred in relatively natural settings, wildlife in urban systems may be exposed to particularly high levels of human recreation. The consequences of increased exposure to recreation, however, remain unclear, in that wildlife may become desensitized to recurrent human disturbances in some situations but not others, and such habituation may have both beneficial and negative impacts (Knight and Gutzwiller, 1995; Whittaker and Knight, 1998; Taylor and Knight, 2003; Kloppers et al., 2005; Magle et al., 2005; Smith et al., 2005).

Highly urban regions are often characterized by rapid expansion, which leads to habitat loss and fragmentation, the primary threat to endangered species in the United States (Wilcove et al., 1998). Widespread urbanization, in combination with high levels of species endemism and diversity, has created a major 'hot-spot' of extinction in coastal southern Californian natural communities (Myers, 1990; Dobson et al., 1997). Orange County, California, is one such coastal region to experience massive human population growth. Between 1950 and 1990, Orange County's population increased 10-fold, from approximately 200,000 to over 2,400,000 (State of California, 2001), with a projected population of nearly 3.2 million in 2010 (State of California, 2004). In response to urban sprawl and resultant habitat fragmentation, The Nature Reserve of Orange County (NROC) was created to preserve some of the region's last remaining natural areas. Although the NROC protects over 150 km^2 of open space, housing and commercial units encircle and fragment the reserve, and development is continuing. The NROC is permeated by foot and bike trails, maintained dirt roads, and dry creek beds, which can serve, in varying degrees, as movement routes for local wildlife as well as human recreationists, such as hikers, bicyclists, horseback riders, and dog walkers.

The goal of this study was to investigate the relationship between large mammal activity patterns and human recreation in an urban nature reserve. We assessed the spatial and temporal activity patterns of bobcat (*Lynx rufus*), coyote (*Canis latrans*), and mule deer (*Odocoileus hemionus*), as well as humans and domestic dogs, using infra-red remotely triggered cameras, valuable survey tools because they can record daily activity patterns for an extended period of time with minimal supervision (Carthew and Slater, 1991; Cutler and Swann, 1999; Carbone et al., 2001). We hypothesized that in areas of higher human recreation, large mammals would exhibit lower trail use, particularly during the daytime when human recreationists are most active.

2. Methods

2.1. Study area

The NROC is a reserve system spanning the central portion of Orange County, California. Human recreation in the reserve varies due to differing restrictions. Many parcels allow recreation on a daily basis and often year-round. Human recreation activity is consistently high in these areas, both throughout the daytime hours and throughout the year. Other parcels are limited to docent-led tours (e.g. lands managed by The Nature Conservancy) or completely closed to the general public. These areas typically receive relatively low levels of human activity throughout the year, although trespassing does occur. Much of the NROC, including areas with both high and low levels of human recreation, supports native habitat and wildlife communities.

The reserve is divided into two core areas: the coastal sub-region (ca. 73 km^2) and the central sub-region (ca. 77 km^2). The coastal sub-region is bordered by the Pacific Ocean to the southwest and by cities in all other directions. The central sub-region is located at the northwestern terminal portion of the Santa Ana Mountain range. It is connected to the Cleveland National Forest to the east and bordered by cities in all other directions. The city of Irvine and major freeway systems separate the two sub-regions and, at present, there are few to no viable habitat corridors for large mammals connecting the two portions of the reserve.

Coastal southern California has a Mediterranean type climate with an average annual precipitation level of less than 38 cm per year and two seasons: dry (June–November) and wet (December–May). The majority of our large mammal surveys (86% of sampling effort) occurred in the dry season, although some sampling at some sites continued into the early wet season. Coastal sage scrub, chaparral, and oak woodlands are the dominant habitat types within the NROC, although open grasslands and riparian habitat also exist. Percent cover of native and exotic plant species was estimated within a 20-m radius of each sampling station by following a modified Braun-Blanquet categorical scale (Kent and Coker, 1992). The cover scale was 0 (absent), 1 (<1%), 2 (1–5%), 3 (6–25%), 4 (26–50%), 5 (51–75%), and 6 (76–100%). Cover types were categorized as: (1) trees, including both native and non-native species; (2) native shrubs; and (3) exotic vegetation.

2.2. Spatial displacement (relative activity)

During 1999–2001, we used remotely triggered cameras (CamTrakker, Inc., Watkinsville, GA) to record the presence