

Wildlife Response to Human Recreation on NCCP Reserves in San Diego County

SARAH E. REED^{1,2}, COURTNEY L. LARSON², KEVIN R. CROOKS² and ADINA M. MERENLENDER³

¹North America Program, Wildlife Conservation Society

²Department of Fish, Wildlife & Conservation Biology, Colorado State University

³Department of Environmental Science, Policy & Management, University of California

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Executive Summary

Adaptive land protection and management strategies are fundamental to accomplishing the stated species and habitat conservation goals of federal Habitat Conservation Plan (HCP) and California Natural Community Conservation Plan (NCCP) efforts. In San Diego County, the current NCCP reserve system includes more than 200,000 acres of protected lands, which are monitored and managed by multiple jurisdictions. The Wildlife Agencies (FWS and DFW, collectively), environmental groups, and reserve managers would like an improved understanding of how various threats and stressors may be affecting reserve performance for the benefit of 103 plant and animal species. The intent of this applied research project was to complement the existing species and habitat monitoring efforts in San Diego County by developing a program to assess the possible effects of human recreation on wildlife populations. Specific objectives were to: (1) Develop recommendations for a research for studying the effects of recreation on wildlife species; and (2) Test methods for monitoring recreation and complete a pilot field study.

There is a growing awareness that even quiet, non-consumptive recreational activities, such as hiking and wildlife viewing, can affect the distribution and abundance of some animal species within protected areas. Outdoor recreation has many human health and economic benefits; it also influences people's political and financial support for land and wildlife conservation. Although the negative effects of extractive and consumptive land uses within protected areas are well known, outdoor recreation is often assumed to be compatible with species protection. However, a growing body of research demonstrates that outdoor recreation can negatively impact plant and animal communities. Recreation is the second-leading cause of endangerment to species occurring on U.S. federal lands, and of all U.S. states, California has the greatest number of listed species threatened by recreation. Land and wildlife managers are seeking solutions to balance the benefits of outdoor recreation for human communities with its potentially negative effects on species and ecosystems.

We completed several major activities to meet our objectives for this project. First, we implemented a systematic review of studies examining the impacts of recreation on wildlife, in order to assess what has been studied and where gaps in knowledge remain, which species are particularly vulnerable, and what types of effects are the most prevalent. We found that studies of the effects of recreation focus most frequently on mammals and birds, and least frequently on reptiles, fish, and amphibians. Geographically, most studies have been conducted in Western Europe, North America, and Australia. The most commonly studied effects of

recreation are behavioral responses and changes in abundance, whereas diversity and survival are rarely studied. Studies of individual- and community-level responses detected significant (and typically negative) effects more often than studies of population-level responses.

Second, we acquired and augmented a geographic information system (GIS) database to facilitate field site selection and spatial analysis. We identified a list of 89 NCCP reserves (> 100 ha) that are managed by federal, state, or local government entities. From this list, we worked with SDMMP staff members to select 51 reserves for the expert opinion survey and 18 reserves for the pilot field study. Because representations of trail networks in the selected reserves often were not available as a GIS data layer from the collaborating agencies, we also created a spatial database of official and unofficial (user-created) recreation trails digitized from aerial imagery. In total, we mapped 1,206 km of trails in 19 reserves, and we found that unofficial or user-created trails comprise a mean of 45% of the trail networks mapped per reserve (range: 8-85%).

Third, at the advice of many agency personnel during early project scoping meetings, we conducted an expert opinion survey to assess relative levels of visitation to a subset of NCCP reserves. The survey was sent by the collaborating agencies to rangers and other knowledgeable reserve staff. For each reserve, the respondents were asked to estimate the number of visitors on an average weekday and weekend day, by season and type of recreation, and during special events. The survey received responses from 35 rangers and reserve managers from seven agencies. Reserves with the highest overall reported levels of recreation include Mission Trails, Iron Mountain, and Torrey Pines. Reserves with the lowest reported levels are Boden Canyon, Plaisted Creek, and San Felipe Valley. Generally, seasonal variation in visitation corresponds with reserve location, with reserves on or near the coast experiencing lower use in the winter, and reserves located further inland experiencing lower use in the summer. Hiking is the most common recreational activity reported for all of the reserves, followed by biking. Most respondents (79%) reported some kind of unauthorized use, and several comments indicated a desire for increased ranger presence to protect sensitive natural areas.

Fourth, we implemented a pilot field study to test methods for monitoring recreation visitation and provide a more precise quantitative estimate of actual visitation rates at 18 NCCP reserves. In the pilot study, we found that remotely-triggered cameras were the most efficient and cost-effective technique currently available for counting visitors to reserves; however, visitor counts from remotely-triggered cameras should be calibrated with timed visual observations, to estimate error rates and convert raw data into reliable visitation estimates. To design the sampling strategy for the pilot field study, we counted all official entrances to each site and stratified them into three categories: staging areas, trail heads, and connectors. At each reserve, we sampled all staging areas and a random selection of at least half of the other entrance types for one 2-week period. A total of 142,456 photos were taken over the course of the study. On average, 68% more photos were taken on weekend days than on weekdays. On weekdays, peaks in activity occurred in the morning and evening, whereas on weekend days, peaks occurred in the morning. To a large degree, relative levels of visitation among reserves reflect the results of the expert opinion survey. Mission Trails had by far the greatest visitation levels among the reserves sampled, but Los Peñasquitos Canyon, Blue Sky, and Iron Mountain also receive substantial recreation use. We did not detect any recreational visitors at Boulder Oaks, and very few at San Vicente Highlands.

We conclude this report with our recommendations for a research design to study potential impacts of recreation on wildlife species in the diverse NCCP reserves across San Diego County and next steps for communicating the results of this project to scientists, land and wildlife managers, and the public.

Background and Objectives

Adaptive land protection and management strategies are fundamental to accomplishing the stated species and habitat conservation goals of federal Habitat Conservation Plan (HCP) and California Natural Community Conservation Plan (NCCP) efforts. These conservation plans are intended to provide long-term protection of multiple endangered species via mitigation for individual development projects, based on requirements of the federal Endangered Species Act (ESA) and California Endangered Species Act, as implemented through the California Environmental Quality Act (CEQA). They are also intended to provide the development community with greater certainty about where development projects could or could not take place and allow for faster approval processes. The California NCCP Act (2003) mandates that all NCCPs implement an adaptive management approach, including opportunistic learning, hypothesis testing, and directing the results of analysis and assessment back into management and monitoring programs.

In San Diego County, the current NCCP reserve system includes more than 200,000 acres of protected lands, which are monitored and managed by multiple jurisdictions. These include the City and County of San Diego; Cities of Chula Vista, Carlsbad, and Poway; U.S. Fish and Wildlife Service (FWS); California Department of Fish and Wildlife (DFW); Bureau of Land Management; San Dieguito River Joint Powers Agency; and others. The Wildlife Agencies (FWS and DFW, collectively), environmental groups, and reserve managers would like an improved understanding of how various threats and stressors (e.g., recreational use, invasive species, fire, and urban runoff) may be affecting reserve performance for the benefit of 103 plant and animal species such as cactus wren (*Campylorhynchus brunneicapillus*), golden eagle (*Aquila chrysaetos*), San Diego horned lizard (*Phrynosoma coronatum*), burrowing owl (*Athene cunicularia*), and mule deer (*Odocoileus hemionus*).

The intent of this applied research project was to complement the existing species and habitat monitoring efforts in San Diego County by developing a program to assess the possible effects of human recreation on wildlife populations. The project contributes to two key NCCP goals: 1) Conserve the diversity and function of the ecosystem through the preservation and adaptive management of large blocks of interconnected habitat and smaller areas that support rare vegetation communities; and 2) Conserve specific species at levels that meet the standards of the federal ESA and California's NCCP Act. Assessing the possible effects of recreation, a potentially significant stressor for some species of concern, will allow entities responsible for reserve management to adaptively manage public access to reduce negative impacts of recreation on species persistence and ecosystem function across the reserve network.

There is a growing awareness that even quiet, non-consumptive recreational activities, such as hiking and wildlife viewing, can affect the distribution and abundance of some animal species within protected areas. Outdoor recreation has many human health (Frumkin 2001) and economic benefits (Goodwin 1996); it also influences people's political and financial support for land and wildlife conservation (Zaradic et al. 2009). Although the negative effects of extractive and consumptive land uses within protected areas are well known (e.g., Liu et al. 2001), outdoor recreation is often assumed to be compatible with species protection (Reed & Merenlender 2008). However, a growing body of research demonstrates that outdoor recreation can negatively impact plant and animal communities (Liddle 1997). Recreation is the second-leading cause of endangerment to species occurring on U.S. federal lands (Losos et al. 1995). Of all US states, California has the greatest number of listed species threatened by recreation, in part because the threat of recreation is most frequently associated with urbanization, another important cause of endangerment (Czech et al. 2000). Although more public policy has focused on the potential impacts of motorized recreation (E.O. 11644; E.O.

11989; USFS 2005), negative effects of quiet, non-consumptive activities such as hiking, biking, and horseback riding have been demonstrated for a variety of taxa in a range of terrestrial habitats (George & Crooks 2006; Reed & Merenlender 2008; Rogala et al. 2011). Recreation activity has been linked to declines in wildlife species occupancy, abundance and density (Banks & Bryant 2007; Reed & Merenlender 2008), changes in spatial or temporal habitat use (George & Crooks 2006; Cardoni et al. 2008), increased physiological stress (Arlettaz et al. 2007), reduced reproductive success (Finney et al. 2005), and behavioral effects such as increased vigilance and flight (Taylor & Knight 2003). Thus, the recreational use of reserves, or certain types of recreational activities, may not always be compatible with achieving the species conservation goals of the NCCP reserve system.

Participation in outdoor recreation and rates of visitation to protected areas are increasing rapidly in the U.S. (Cordell 2008) and around the world (Balmford et al. 2008). Land and wildlife managers are seeking solutions to balance the benefits of outdoor recreation for human communities with its potentially negative effects on species and ecosystems (Hadwen et al. 2007). Although prior studies provide valuable data on the behavioral responses of individual wildlife species to specific recreational activities, they rarely address the landscape- or community-level effects of recreation. Few studies have examined recreational impacts in multiple sites within a reserve network (e.g., Forrest & St. Clair 2006) or made comparisons between sites that do and do not permit recreation (e.g., Reed & Merenlender 2008). Similarly, few studies have addressed the impacts of recreation on multiple species. For example, in a recent literature review of avian responses to human disturbance, only 21 percent of studies included multiple species (Blumstein et al. 2005). Landscape-level studies of the effects of recreation on wildlife communities are needed in order to understand which species are most likely to be sensitive to human recreation and in which locations those species are exposed to a level of human use that exceeds their threshold of disturbance, with potentially negative population- and community-level consequences. The diversity of species and habitats in San Diego County and spatial and temporal variation in the type and intensity of recreational activities indicate the need for careful planning when designing a study to investigate the effects of recreation across a multi-jurisdictional reserve network designed for multiple species conservation.

The main objectives for the first phase of this collaborative applied research project were to:

- 1) Develop recommendations for a research design in collaboration with local researchers and managers for studying the effects of recreation on wildlife species to inform adaptive management decisions and meet the conservation objectives of the San Diego NCCP reserves; and
- 2) Test methods for monitoring levels of recreational disturbance and complete a pilot field study, which will be used to improve the research design and maximize our ability to detect the possible effects of recreation on multiple species.

The applied research grant agreement supporting this project (#P1182112) was finalized in April 2012. Principal collaborators include Dr. Sarah Reed, Associate Conservation Scientist with the Wildlife Conservation Society; Dr. Adina Merenlender, Adjunct Professor and Extension Specialist at the University of California, Berkeley; and Dr. Kevin Crooks, Professor at Colorado State University. In August 2012, Ms. Courtney Larson joined our team as a Graduate Research Assistant. Courtney successfully defended her M.S. thesis proposal in April 2013, completed her comprehensive exam in May 2013, and she will complete her M.S. degree in Fall 2014 at Colorado State University.

Literature Review

A recent, thorough, and systematic review of studies examining the impacts of recreation on wildlife does not exist. Previous reviews are limited, restricting their scope by location or habitat type (Boyle & Samson 1985; Marzano & Dandy 2012), taxonomic group (Wolfe et al. 2000; Stankowich 2008; Martínez-Abraín et al. 2010; Steven et al. 2011), or type of recreation (Orams 2002; Newsome et al. 2004). Several reviews provide a descriptive summary rather than any quantitative analysis (Knight & Cole 1995; Wolfe et al. 2000; Marzano & Dandy 2012), and others report only a net positive or negative effect of recreation on each species studied (Boyle & Samson 1985; Steven et al. 2011). Knight and Cole (1995) provide a valuable overview including numerous types of recreation and all terrestrial taxa, but this review is now dated. We are not aware of any existing reviews on aquatic taxa.

To assess the current state of our knowledge of recreation impacts on wildlife, we are conducting a systematic review of the peer-reviewed scientific literature (Pullin & Stewart 2006). This review includes all animal taxa, all types of non-consumptive recreation, and all terrestrial and aquatic habitats. The breadth of this review will allow for a comprehensive assessment of what has been studied and where gaps in knowledge remain. It will enable us to assess which species are particularly vulnerable and what types of effects are the most prevalent (e.g., changes in behavior, abundance, or survival).

The review addresses the following questions:

- 1) Which taxa, habitats, geographic areas, and types of recreation have been studied?
- 2) Which species are the most sensitive to the effects of recreation? What types of responses are most frequently measured, and which of these most frequently detect a statistically significant effect?
- 3) Which types of recreation have the greatest effects? What management recommendations are provided for managing or mitigating the effects of recreation?

Methods

We searched for papers within a broad list of scientific journals, aiming to capture papers published in regional or lesser-known journals as well as the most widely read publications. The list was comprised of journals from four categories of Journal Citation Reports within the Institute for Scientific Information (ISI) Web of Science: biodiversity conservation, ecology, zoology, and behavioral sciences. Within the list of journals, we used the keywords “touris*” and “recreat*” to search for recreation and tourism papers in Web of Science. We did not include taxonomic keywords since papers often refer to only their focal species rather than to broader taxonomic groups. Using the titles and abstracts, we determined whether a paper would be included or recorded the reason for rejection (Pullin & Stewart 2006).

We recorded information from each of the papers in the final list, including data on species, geographic location, predictor and response variables, effect, and management recommendations. Predictor variables include the specific aspects of recreation that were measured (e.g., number of visitors per day). Response variables include the measures of wildlife responses (e.g., nest success). Effect includes whether the researchers detected a statistically significant effect of recreation on wildlife and the direction of the effect (e.g., nest success was higher at sites with fewer visitors). We summarized the number of papers by taxonomic group, location, year of publication, type of recreation, response variable measured, experimental design, and other categories.

Results

The keyword search produced an initial list of 1,770 papers. Using the titles and abstracts (and, where necessary, the full text) we determined whether the paper would be included. Reasons for excluding a paper were: a) did not measure response variables on one or more animal species; b) did not include some type of recreation as a predictor variable; c) did not collect empirical data (e.g., they were review or simulation modeling papers); d) studied the effects of recreation infrastructure (e.g., ski lifts) rather than recreation activity; or e) examined recreation as a vector for invasive species dispersal or disease transmission. This resulted in a list of 231 included papers from which data were extracted (Appendix 1).

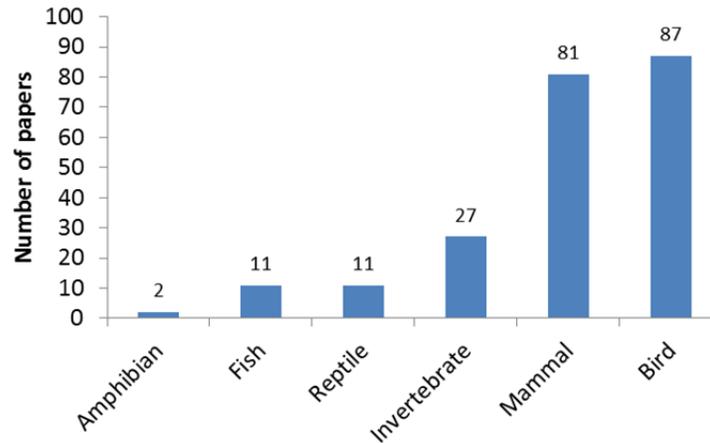


Figure 1. Distribution of papers by broad taxonomic group

As expected, studies of the effects of recreation and wildlife most frequently focus on mammals and birds (37% and 40% respectively; Figure 1). A surprisingly high proportion of studies (12%) focus on invertebrates. Most of these are part of a sizable literature on the effects of recreational scuba diving and snorkeling on corals. It is also notable that only two studies included an amphibian species. Geographically, most of the studies were located in western Europe, North America, and Australia (Figure 2). Studies located in Antarctica represent concerns about how a growing tourism industry may affect the wildlife, particularly penguins.

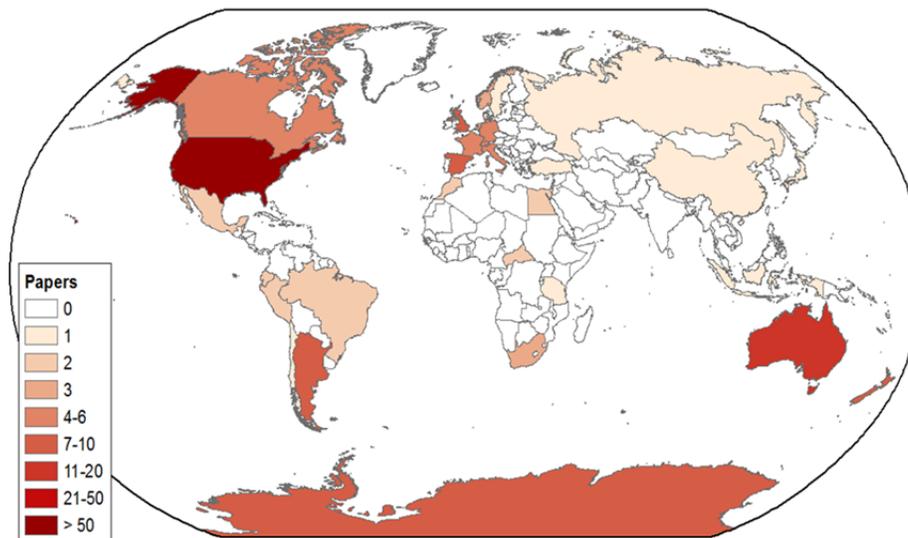


Figure 2. Geographic distribution of papers.

We collected data on specific findings within papers to examine the effect of recreation on narrower taxonomic groups, the differences between types of recreation, and the types of responses to recreation. For example, if a study examined the effects of hiking on five behavioral responses of two shorebirds species, that study would contain ten “findings”. For each finding, we recorded whether the authors observed a statistically significant effect, and the direction of the effect.

The most commonly studied effects of recreation are behavioral responses (Figure 3), perhaps because they are easier to measure or detect, followed by responses in abundance. Diversity and survival responses are rarely studied. The most commonly measured variables are not always the ones that frequently observe significant effects. Population-level responses tend not to find as many significant effects as individual and community-level responses.

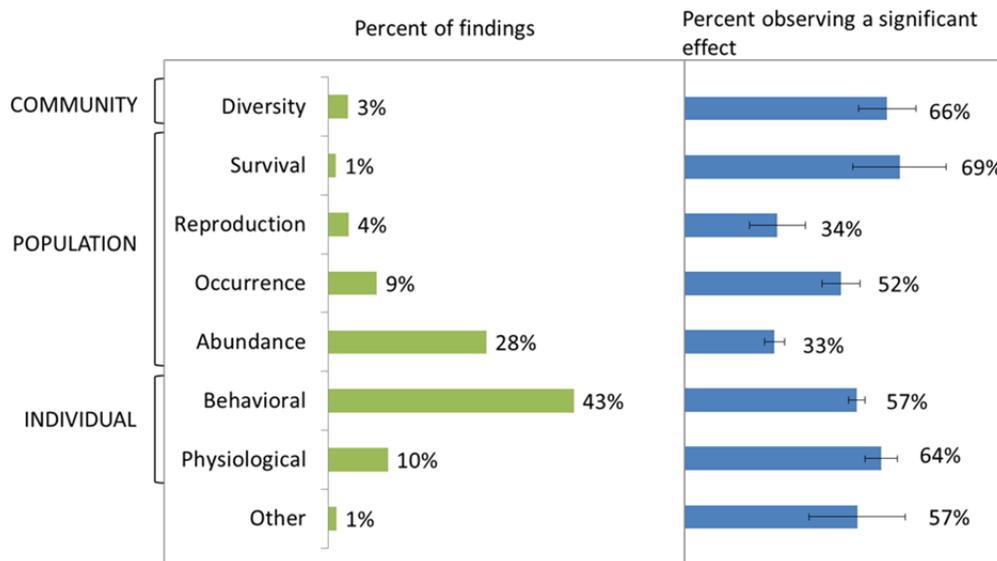


Figure 3. Findings by type of response, compared to the percent of those findings that observed a significant effect. The total number of findings represented here is 1,010.

When we examined the percent of findings that observed a significant effect by broad taxonomic group, there were no obvious trends; all groups averaged close to 50% (Figure 4). This suggests that our taxonomic categorization was too broad to see real effects. Accordingly, we broke down birds and mammals (the best-studied groups) into taxonomic orders (Figure 5). The orders show a wider range of variation, but the drivers of this variation remain somewhat unclear.

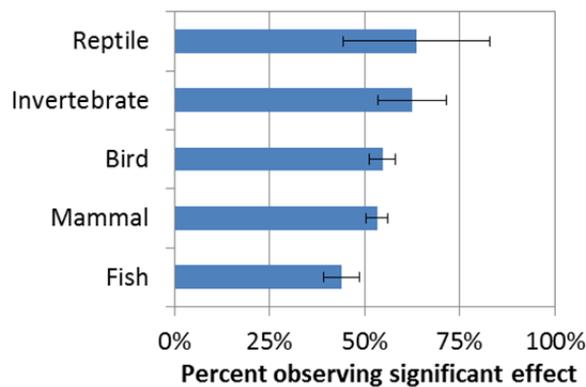


Figure 4. Studies observing a significant effect by taxonomic group.

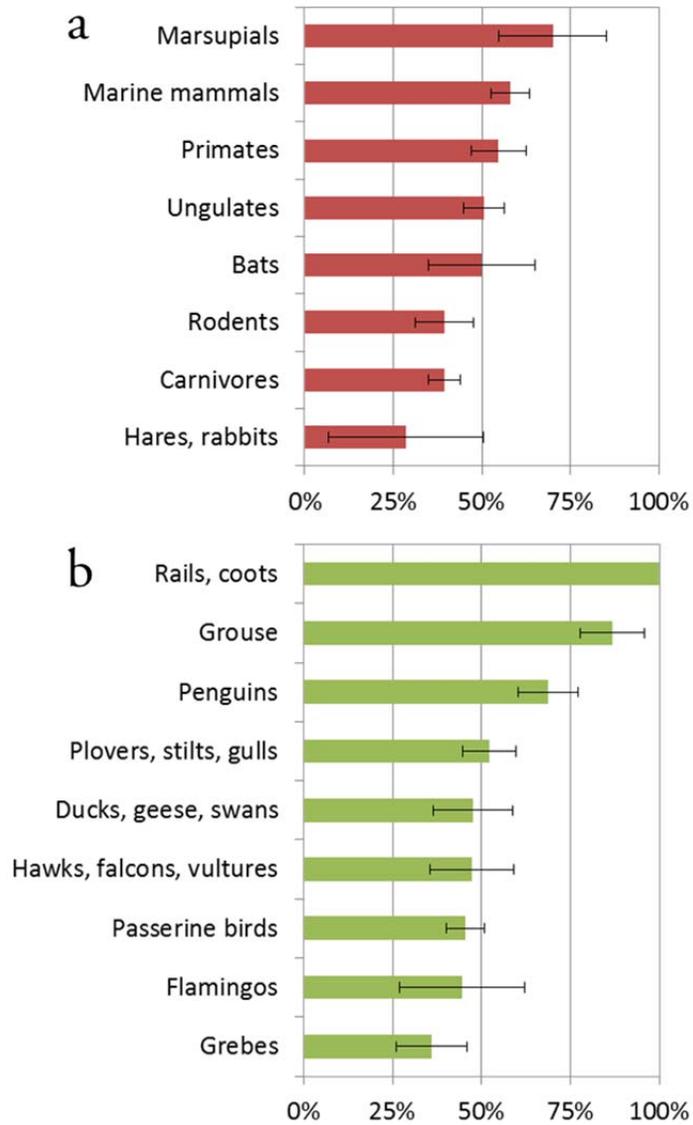


Figure 5. Studies observing a significant effect by a) mammalian orders, and b) avian orders. Order names are shown as the common names of species or groups of species within that order. The total numbers of findings were: 444 (mammals) and 370 (birds).

GIS Database

The San Diego area has a large number of conserved areas that vary by type and managing agency. One of the first tasks in the project was to identify appropriate study sites. The goal was to select sites that would represent a likely gradient in recreational use, and that would also vary in other characteristics such as size, length of trails, permitted recreational uses, and surrounding land uses.

We started the site selection process with a GIS data layer including all conserved lands in San Diego County. We removed all areas not managed by federal, state, or local government entities (e.g., areas owned by private citizens, land trusts, or homeowners associations), and all areas that were smaller than 100 hectares. Given limited time and resources, we decided to focus our field monitoring effort on the larger reserves since they are more likely to support populations of sensitive species. Further, in discussions with SDMMP and city, county, and state personnel, the larger reserves (rather than small urban canyon reserves) were frequently mentioned as places where this research was most needed. The resulting list of 89 areas was sent to SDMMP staff members, who are more familiar with the conserved lands in the area and provided suggestions about which reserves to include in the expert opinion survey and pilot field study. They also helped identify known errors in the names and boundaries of the reserves in the GIS data layer. This list was reduced to 51 reserves for the expert opinion survey (Appendix 2), and to 18 reserves for the pilot field study (Table 1). Generally, the sites selected for field surveys were well-known to SDMMP staff, and wildlife studies have been conducted on many of them. We also made sure to include some reserves (Boulder Oaks and San Vicente Highlands) that are closed to public access because we assume that they will have the lowest levels of use. The resulting database of reserve locations, names, and boundaries is substantially improved and will likely be useful for other researchers and managers working at a landscape-scale in the NCCP reserve system.

Table 1. NCCP reserves included in the pilot field study.

Reserve	Managing agency
Barnett Ranch Open Space	County of San Diego
Black Mountain Open Space Preserve	City of San Diego
Blue Sky Ecological Reserve	California Dept of Fish & Wildlife, City of Poway
Boulder Oaks Open Space Preserve	County of San Diego
Carmel Mountain Open Space Preserve	City of San Diego
Crestridge Ecological Reserve	California Department of Fish & Wildlife
Del Dios Highlands Open Space Preserve/Elfin	County of San Diego, Olivenhain Water District
Forest Recreational Reserve	
Del Mar Mesa	City of San Diego, U.S. Fish & Wildlife Service
Hollenbeck Canyon Wildlife Area	California Department of Fish & Wildlife
Iron Mountain	City of Poway
Los Penasquitos Canyon Preserve	City of San Diego, County of San Diego
Mission Trails Regional Park	City of San Diego
Ramona Grasslands Preserve	County of San Diego
San Diego National Wildlife Refuge	U.S. Fish & Wildlife Service
Simon Preserve	County of San Diego
San Vicente Highlands Open Space Preserve	California Department of Fish & Wildlife
Sycamore Canyon/Goodan Ranch Preserve	County of San Diego
Tecolote Canyon Natural Park	City of San Diego

Recreational Trails

Representations of trail networks in the selected reserves were sometimes available as a pdf or paper map, but were not available as a GIS data layer from the collaborating agencies. Because locations of entrances to the reserves and the length and density of the trail network are critical for our research design, and the shrub and chaparral vegetation of the area allows for trails to be distinguished fairly easily from high resolution aerial imagery, we decided to create the data using heads-up digitizing methods. Ms. Andra Bontrager, GIS Specialist at WCS, completed this work.

Trails were identified as non-natural linear features that differed from natural landscape features (e.g., stream channels) and had a recognizable network pattern connecting them to the known trail system. Existing trail maps were used when possible to identify official trails. Trail features were identified at a scale of 1:5,000 and created at a scale between 1:2,000 and 1:1,000 using imagery from ArcGIS online servers. Each trail feature was assigned attributes that noted characteristics of the trail feature. These attributes were network order (primary, secondary, or tertiary), approximate width of the trail, and confidence rating (Appendix 3, Table 2).

Table 2. Summary of trail digitizing work for NCCP reserves.

Reserve	Area (ha)	Segments (<i>n</i>)	Trail length (km)			Total
			Primary	Secondary	Tertiary	
Barnett Ranch	301.4	89	4.41	2.57	9.94	16.92
Black Mountain	1088.6	212	24.63	17.68	14.91	57.21
Blue Sky	306.7	141	5.78	7.79	13.17	26.74
Boulder Oaks	513.0	42	5.25	4.93	5.73	15.91
Carmel Mountain	166.5	122	12.45	10.40	1.96	24.81
Crestridge	1064.9	292	12.28	19.93	36.99	69.20
Del Dios & Elfin Forest	530.4	167	17.64	13.34	11.69	42.67
Del Mar Mesa	257.3	101	3.24	6.99	21.98	32.22
Hollenbeck Canyon	2473.2	234	16.90	9.90	78.87	105.68
Iron Mountain	358.0	60	5.13	6.40	3.79	15.33
Los Peñasquitos Canyon	1387.4	369	31.20	29.44	53.58	114.21
Mission Trails	2076.6	519	70.46	70.90	43.24	184.59
Otay Valley	181.7	164	8.91	13.62	5.87	28.40
Ramona Grasslands	1574.6	198	3.84	7.74	64.92	76.50
Rancho Jamul	2316.6	418	20.63	34.14	64.54	119.31
San Vicente Highlands	644.0	73	6.20	10.91	8.81	25.91
San Diego National Wildlife Refuge	3178.4	559	35.75	62.05	92.69	190.50
Simon Preserve	249.8	129	8.74	11.55	6.51	26.80
Sycamore Canyon/Goodan Ranch	1033.5	81	11.92	15.99	5.32	33.23

The digitized trails include unofficial (i.e., social or user-created) trails in addition to official recreational trails. Though we were not able to separate official from unofficial trails, we expect that in general, the primary trails are official trails and the tertiary trails are unofficial. In some reserves such as Hollenbeck Canyon and Ramona Grasslands, tertiary (presumably unofficial) trails make up the majority of the trail network. To the best of our knowledge, this information was not previously available. This dataset, including

the accompanying metadata, will be shared with reserve staff, who may wish to use it to target sign placement or enforcement actions, or in the design of future research studies.

Expert Opinion Survey

Despite recent increases in outdoor recreation (Cordell 2008) and concern about its impacts, protected area managers rarely have adequate data on even the most basic of visitation measures. Understanding current visitor use can help managers identify hotspots of particularly high visitation, allocate services and staff, and monitor compliance with regulations (Cessford & Muhar 2003). This information can help managers determine policies to minimize detrimental effects of recreation on wildlife, such as keeping visitors out of sensitive areas, limiting hours of use, limiting certain types of recreational activities, restricting the number of visitors, or implementing visitor education efforts (Liliehalm & Romney 2000).

Through conversations with wildlife and land management agency staff, we were unable to identify a consistent source of visitor use data for NCCP reserves within the San Diego study area. However, most of the reserves have rangers and other on-the-ground personnel who are familiar with the reserves and their relative rates of visitation. Therefore, as a simple way to approximate visitor counts for a large number of reserves, we chose to systematically document the expert opinion of reserve staff and volunteers. Although there are few published examples of systematic surveys of experts, evidence suggests that reliance on informal expert knowledge is commonplace (McLaran & Cole 1993; Cessford & Muhar 2003).

Methods

We developed an expert opinion online survey to systematically gather information regarding recreational visitation to NCCP reserves in San Diego County. The survey asked respondents to choose the reserves with which they are most familiar from a list of reserves that included all parks, ecological reserves, and open space preserves that are managed by federal, state, or local government agencies (see GIS Database, above). The list also included reserves that are closed to recreation in order to collect information on possible unauthorized use. Starting in May 2013, the online survey was sent by the land management agencies to rangers and other knowledgeable reserve staff.

For each reserve chosen, respondents were then asked about the number of visitors on an average weekday and weekend day, on average days during each season, during special events, and who are participating in different types of recreation. The survey also asked about unauthorized use and potential wildlife impacts. Lastly, respondents were asked about the number days during the past year that they spent in each reserve and the number of years they have worked in the reserves, as an approximation of their depth of knowledge and the accuracy of their responses. The resulting data was used to rank the reserves from least to most recreation use in terms of average visitor counts.

Results

The survey received responses from 35 rangers and reserve managers from the Cities of Escondido, Poway, and San Diego; County of San Diego; California Department of Fish & Wildlife; California Department of Parks & Recreation; and U.S. Fish & Wildlife Service.

Each respondent was able to complete the survey for multiple reserves. A total of 69 responses were submitted for 35 reserves. The reserves with the most responses were Torrey Pines State Natural Reserve ($n=6$) and Mission Trails Regional Park ($n=4$). Of the 18 reserves selected for the pilot field study, 14 received responses from the expert opinion survey (Figure 6).

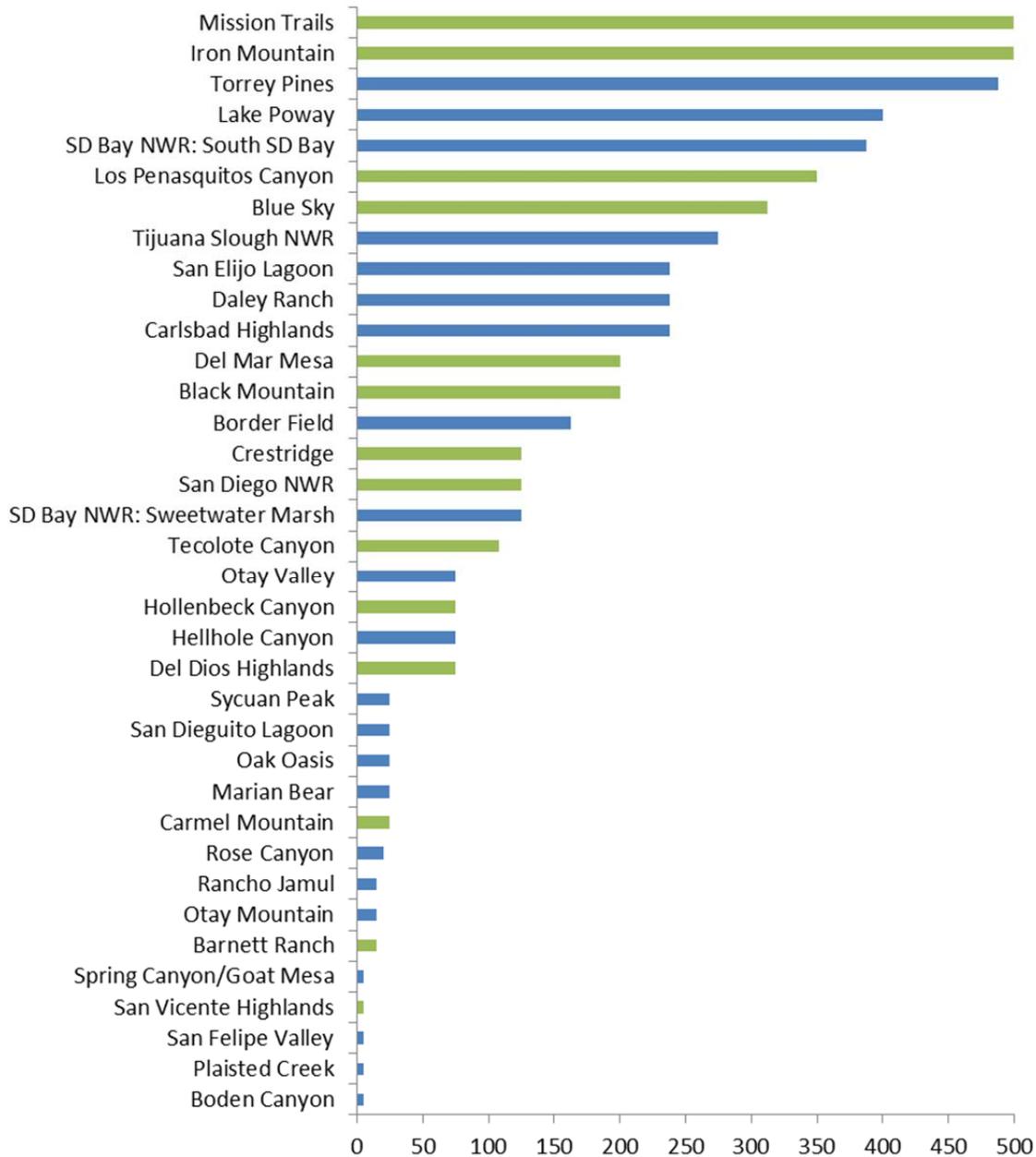


Figure 6. Average number of people entering reserves per day, as estimated by survey respondents. Although responses were given on a 1-5 scale (1 = fewer than 10 people per day; 2 = 10-49 people per day; 3 = 50-199 people/day; 4 = 200-499 people/day; 5 = 500 or more people per day), bars are scaled to the midpoints of the range of values for each category. Green bars indicate reserves that were also included in the pilot field study.

Reserves with the highest overall reported levels of recreation include Mission Trails, Iron Mountain, Torrey Pines, Lake Poway, and a unit of the San Diego Bay National Wildlife Refuge. Reserves with the lowest reported levels are Boden Canyon, Plaisted Creek, San Felipe Valley, San Vicente Highlands, and Spring Canyon/Goat Mesa. As might be expected, average levels of recreation are reported to be higher on weekend days than weekdays. There appears to be seasonal variation in use, but the trend is not consistent across reserves. Some have lower use during the rainy winter season, whereas others show a decline in visitation

during hot summer months. Generally, these responses seem to correspond with the location of the reserve, with reserves on or near the coast showing lower use in the winter, and reserves located further inland showing lower use in the summer.

Hiking is the most common recreational activity reported for all of the reserves, followed by biking (Figure 7). Certain reserves have especially high use by cyclists (e.g., Del Mar Mesa, Los Penquitos Canyon) or equestrians (e.g., Daley Ranch, Border Field State Park). Other recreational activities that were mentioned included seasonal hunting (e.g., Hollenbeck Canyon, Rancho Jamul), beach activities (e.g., Torrey Pines, Tijuana Slough NWR), and hang-gliding (e.g., Black Mountain).

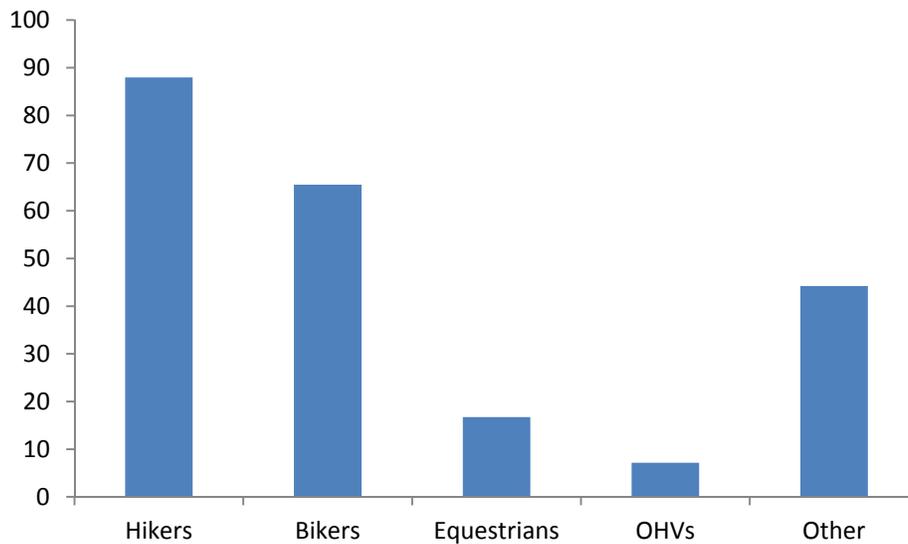


Figure 7. Number of people participating in different types of recreation per day, averaged across all reserves, as estimated by survey respondents. Although responses were given on a 1-5 scale (1 = fewer than 10 people per day; 2 = 10-49 people per day; 3 = 50-199 people per day; 4 = 200-499 people per day; 5 = 500 or more people per day), bars are scaled to the midpoints of the range of values for each category.

Unauthorized use of reserves appears to be quite common; more than three-quarters (79%) of respondents indicate that they are aware of some kind of unauthorized use. These uses vary widely, with some of the more common responses being off-road vehicles, off-trail hiking or biking, after hours use, off-leash dogs, and trash dumping. Several of the general comments left at the end of the survey reflected a desire for increased ranger presence to protect sensitive natural areas from unauthorized use.

Pilot Field Study

To complement the expert opinion survey and provide a more precise quantitative estimate of actual visitation rates, we implemented a pilot field study of recreational visitation to 18 NCCP reserves. In discussions with SDMMP staff, we agreed that monitoring human activity was the priority for the pilot phase of the project. In addition, limited species monitoring data was available at the broad spatial extent that we wished to represent (Appendix 4), and the scientific literature provided little guidance for selecting focal taxa for new surveys. Therefore, to help generate this guidance, we decided to pursue the literature review as an additional activity and to focus the pilot field study on monitoring recreational visitation.

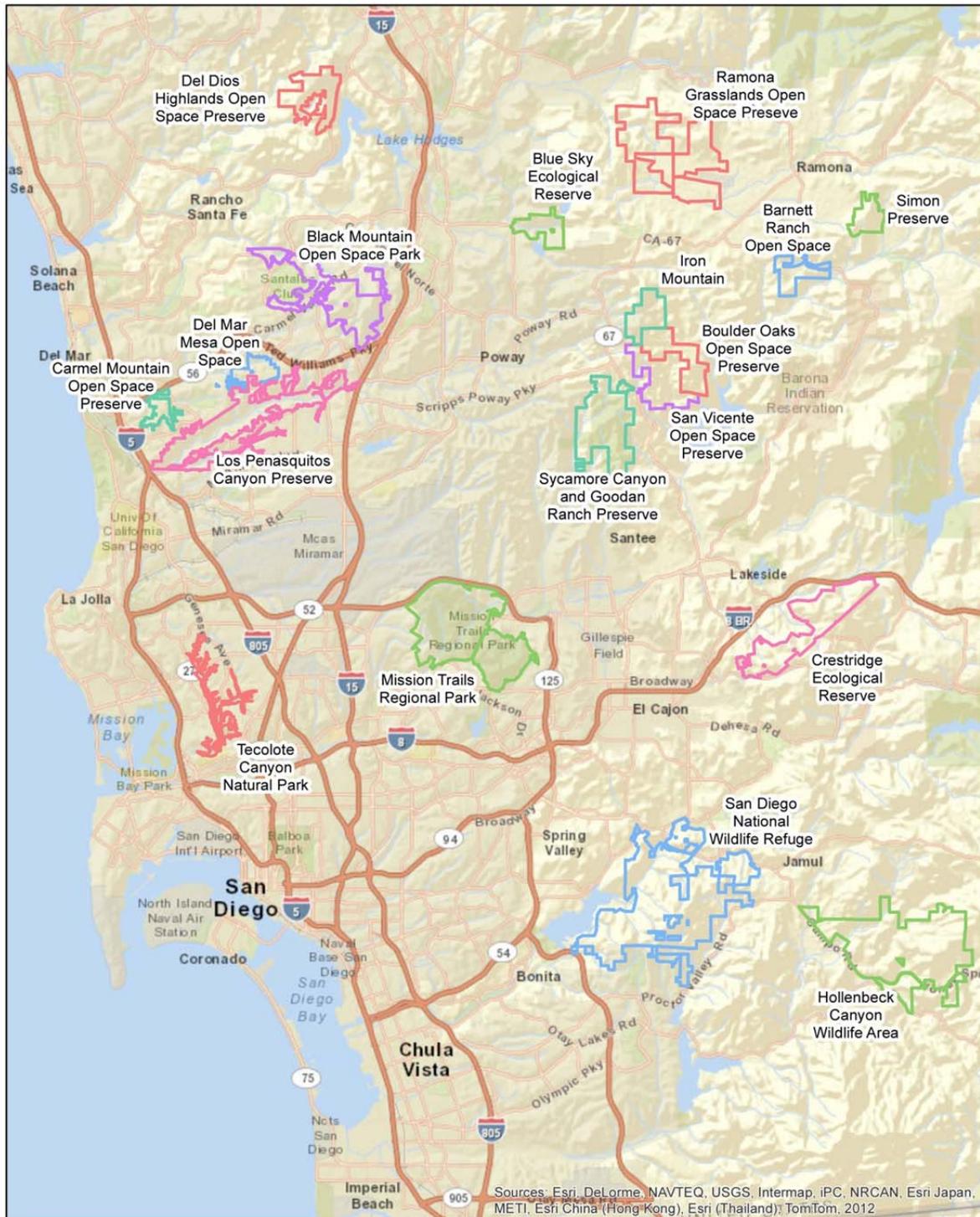
There are several common techniques for counting visitors to protected areas such as direct observations (using human observers), automated methods (such as remotely-triggered cameras or trail counters), visit registrations (permits or visitor logs), inferred counts (proxy variables linked to visitor use, such as parking lot counts), or visitor surveys (in which visitors are asked to provide information about themselves and their use of the reserve). We chose remotely-triggered cameras (Trophy Cam, Bushnell Outdoor Products, Overland Park, MO) as our primary method to monitor visitation because they function similarly to automated trail counters (i.e., use passive infrared light beams to detect passing objects and record the data and time), but compare favorably to trail counters on a cost per unit basis (Table 3). They also provide additional information beyond simple visitor counts, such as number of visitors, type of recreation, and direction of travel.

Table 3. Comparison of trail counter and remotely-triggered camera models considered for use in the pilot study.

Model	Type	Cost/unit	Comments
TrailMaster	counter	\$130-\$260	Only stores 1,000 events. Detects 1 event per 6 seconds on quickest setting. Poor reviews from several people.
TRAFx	counter	\$516	Have to buy as a set of 3 counters
EcoCounter	counter	\$2,675	Records direction of travel. Designed for more permanent installation.
Chambers Electronics	counter	\$1800	Software license \$200.
VIGIL	counter	\$199	Could be an option to explore in the future - was not aware of it when we decided on cameras.
Primos TruthCam	camera	\$137-\$174 including lockbox	Infrared flash, 1.5 second trigger speed
Cuddeback Attack IR	camera	\$234 including lockbox	Infrared flash, 0.25 second trigger speed
LTL Acorn	camera	\$219 including lockbox	Infrared flash, 0.8 second trigger speed
Bushnell TrophyCam	camera	\$170 including lockbox	Infrared flash, 1 second trigger speed

Methods

We conducted field surveys of visitor counts at 18 NCCP reserves from July 22-October 30, 2013 (Figure 8). The sites were selected to represent an approximate gradient in recreational use, based on preliminary results of the expert opinion survey (Figure 6) and conversations with local reserve managers and project partners. All study sites have a total area of at least 100 ha, to eliminate small conservation easements and city parks that are unlikely to be well-known to recreationists or to support populations of sensitive species.



Study sites for fieldwork, summer-fall 2013
 Courtney L. Larson



Figure 8. NCCP reserves selected for field surveys of visitor counts.

To design the sampling strategy for the pilot field study, we counted all official entrances to each site and stratified them into three categories: staging areas, trail heads, and connectors. Staging areas are primary access points with a parking lot (or in a few cases, designated street parking). Trailheads are well-defined entrances that are shown on trail maps and are accessible by car. Connections are not always shown on trail maps, are typically difficult to access by car, and are generally used by people entering from the adjacent neighborhood. At reserves that are partially or completely closed to the public, we sampled service roads near the reserve boundary. These represent the most likely entry points for unauthorized use (and often showed clear signs of visitation). At each reserve, we installed one remotely-triggered camera at all staging areas and a random selection of at least 50% of the other entrance types. The exception was Mission Trails; due to the large number of entrances, we sampled only 3 of 4 staging areas and 1 of 4 connections. At each camera site, we sampled continuously for one 14-day period with four weekend days and ten weekdays. We calibrated counts from the remotely triggered cameras with visual observations to estimate errors and convert raw data into reliable visitation estimates (Pettebone et al. 2010).

We classified each photo into one or more of the following categories: hiker, biker, equestrian, dog, vehicle, non-recreationist (construction and maintenance workers), OHV, research team, wildlife, or blank. In photos containing people, we counted the number of individuals and recorded the direction of travel. At camera sites that had over 2,000 photos during the two week sampling period ($n=22$), we classified a sample rather than a census. To sample the photos, we first calculated the proportion of photos falling into each hour from the frequency distribution of all camera sites (excluding eight camera sites that were heavily affected by wind and thus generated a large number of blank photos). We then randomly selected photos from the sampled sites using those proportions to determine the number taken from each hour, up to a maximum of 2,000 photos. We used this procedure rather than a random or systematic sample because we wanted to ensure we selected the greatest proportion of photos from the times of day when people were most likely to be present.

We estimated recreation use indirectly via systematic parking lot surveys. We surveyed parking lots opportunistically at a subset of the reserves (Blue Sky, Iron Mountain, Mission Trails, and Sycamore Canyon) stratified by time of day (morning, daytime, evening) and day of week. Like the remotely-triggered cameras, this technique requires calibration by establishing a predictive relationship between the number of cars in the parking lot and the number of visitors entering the reserve (Watson et al. 2000).

As a test case to examine how people disperse into the trail network once they enter a reserve, we also placed eight cameras in the interior of one site in addition to the cameras at entrances. We chose Sycamore Canyon for this work because of its relatively simple trail network and expected moderate level of visitation.

The visitor count data will be used to test the validity of the expert opinion survey in the reserves for which both types of information were collected. In addition, both data sources will be used as response variables in a landscape-level spatial model that identifies important variables related to recreational use (see *Next Steps*, below).

Preliminary results

The cameras recorded a total of 142,456 photos over 1,379 camera-nights between July and October 2013. In general, cameras were triggered more often on weekend days than weekdays; over the course of the study 34,085 photos were taken on Saturdays and Sundays, whereas 50,534 were taken on the five days of the week (17,043 per weekend day vs 10,107 per weekday). The distribution of photos over the course of the day also

varied between weekend days and weekdays, with weekdays showing peaks in the morning and evening and weekend days showing the highest amount of activity in the morning (Figure 9.)

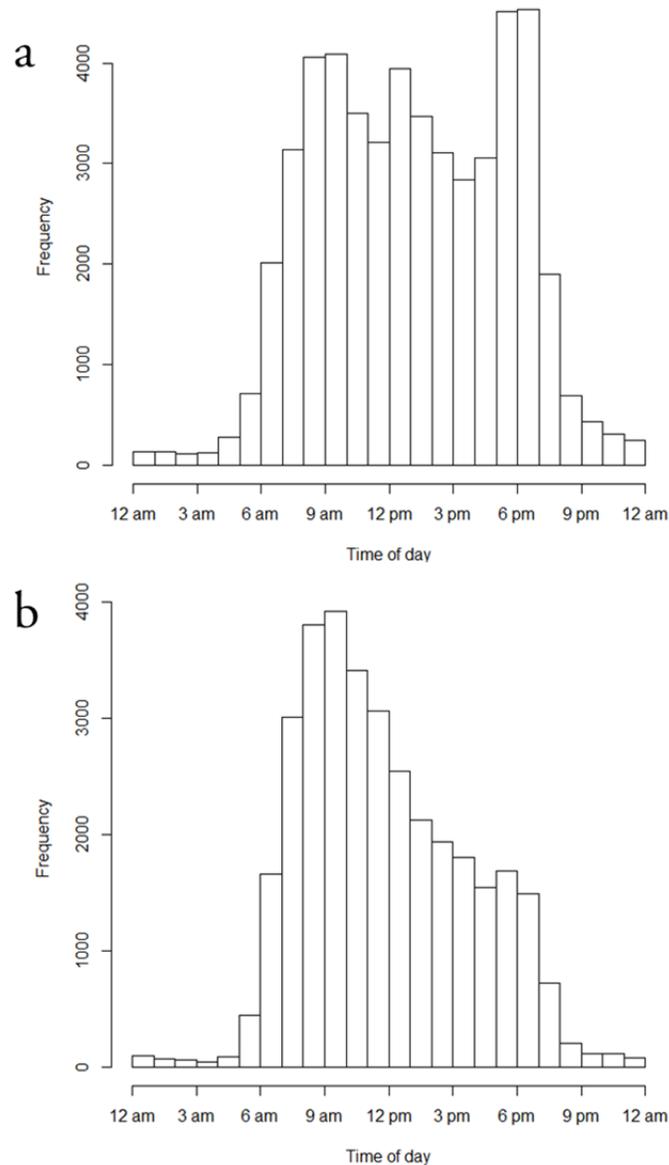


Figure 9. Frequency of photos over the course of the day on a) weekdays and b) weekend days. These histograms exclude eight camera sites where the distribution of photos was skewed due to high wind.

The number of photos summarized by reserve is shown in Table 4. It is important to note that these figures include only those entrances that were sampled. In addition, we have not yet corrected for direction of travel (i.e., visitors entering or exiting the reserves), and so the estimated number of total visitors are likely to be overestimates. Still, we expect that the rank order and magnitude of differences among reserves are accurate. Mission Trails had by far the greatest level of visitation of any of the reserves sampled, but Los Peñasquitos Canyon, Blue Sky, and Iron Mountain also received substantial recreational use. We did not detect any recreational users at Boulder Oaks, and very few at San Vicente Highlands.

Table 4. Mean total number of visitors (hikers, bikers, and equestrians) to NCCP per day, estimated from the remotely-triggered camera data. Parentheses contain the number of entrances sampled out of the total number of entrances of that type. Because the estimates include visitors entering and exiting, they likely overestimate the number of people using the reserve per day.

Site	Staging area	Trailhead	Connection	Service road	Estimated total
Barnett Ranch	50.5 (1/1)		2.3 (1/1)		52.8
Boulder Oaks				0.0 (4/4)	0.0
Blue Sky	551.0 (1/1)		168.7 (1/1)	(0/1)	719.7
Black Mountain	73.2 (4/4)	37.7 (4/5)	11.7 (1/3)		516.4
Carmel Mountain	13.4 (1/1)	37.4 (2/2)	8.3 (2/5)		244.7
Crestridge	52.7 (1/1)	9.0 (1/1)	8.4 (4/7)	(0/1)	297.6
Del Dios/Elfin Forest	154.0 (2/2)		3.2 (1/1)		490.0
Del Mar Mesa			40.6 (3/4)	7.2 (1/2)	502.0
Hollenbeck Canyon	21.4 (1/1)	0.7 (1/1)	4.5 (2/2)	(0/1)	39.9
Iron Mountain	317.0 (2/2)				634.0
Los Peñasquitos Canyon	93.6 (2/2)	180.5 (2/3)	63.9 (3/7)		1,175.9
Mission Trails	526.0 (3/4)	177.4 (6/11)	86.0 (1/4)		4,399.3
Ramona Grasslands	77.5 (1/1)				77.5
San Diego NWR	36.9 (1/1)	37.6 (2/2)	17.0 (3/4)		180.2
Simon Preserve		23.6 (1/1)	5.1 (4/4)		44.0
San Vicente Highlands				0.1 (1/1)	0.1
Sycamore Canyon	27.7 (2/2)		3.5 (2/2)	(0/1)	67.6
Tecolote Canyon	51.9 (2/2)	47.9 (1/2)	17.6 (3/5)		287.9

The results of the interior camera sampling within Sycamore Canyon are shown in Figure 10. The northwest section of the reserve experiences the most recreation visitation. The most frequently used entrance that we sampled is the Goodan Ranch trailhead, though it should be noted that the camera at the Highway 67 entrance only captured visitors going one of three ways out of the parking lot. Tertiary trails (typically unauthorized) experienced little use. Visitation tends to dissipate with increasing distance from entrance points.

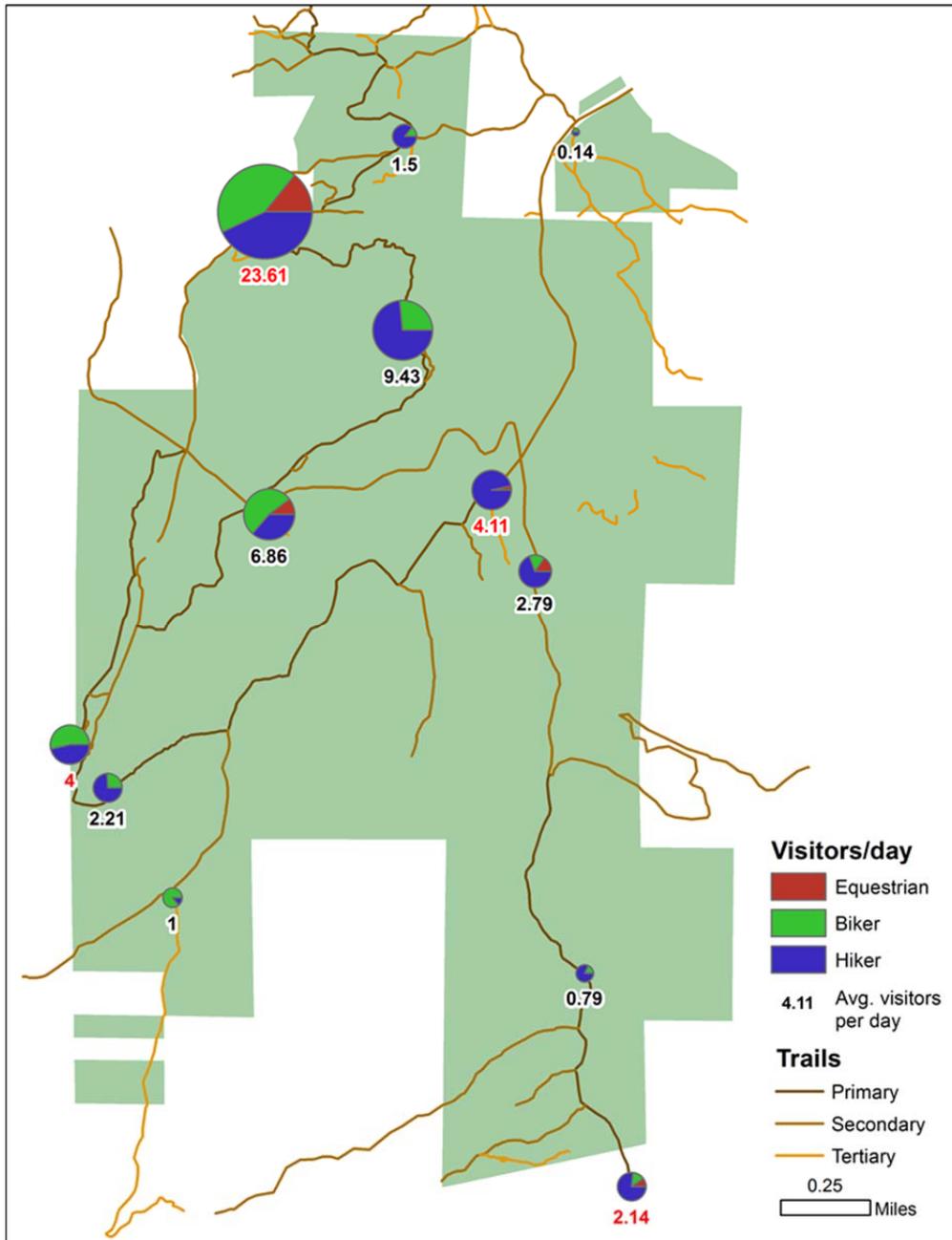


Figure 10. Average visitation per day at four trailheads and eight interior points at Sycamore Canyon. Pie charts show the average visitors per day for the three types of recreation observed in this reserve. The size of the pie chart is proportional to the mean number of visitors per day for all recreation types. Trailheads are denoted with red text, interior points with black text.

Recommendations for Research Design

The ultimate goal of this project was to generate a plan for a longer-term monitoring effort using a scientific framework to examine the potential impacts of recreation on wildlife species across the NCCP reserves. A well-designed study that integrates species monitoring with recreation monitoring is necessary to ensure that the reserves are providing the required levels of protection and achieving the goals of the NCCP program. Wildlife provides significant economic benefits to the State of California through recreation, tourism, and commercial harvest. Many of the places where wildlife thrive are often the same as those valued for recreation and other human activities, and accompanying growth and development is an increasing demand by the public for recreational access to public land, waterways, and ocean resources. In the South Coast region in particular, participation in outdoor recreation and visitation to protected areas will continue to increase in the coming decades. Prior to making any changes in how recreation is managed, systematic monitoring of its direct and indirect effects on wildlife species must be conducted to inform the trade-offs inherent in multiple-use management of protected areas. This monitoring effort will generate an improved understanding of how recreation use may be affecting reserve performance for Covered Species in the San Diego Multiple Species Conservation Program (MSCP) and/or CDFW Species of Special Concern (SSC) and support adaptive management to ensure species persistence and ecosystem function across the NCCP reserve network.

Below, we provide recommendations for a research design for studying the effects of recreation on wildlife species to inform adaptive management decisions. In addition, we include as an appendix a research plan developed from these recommendations and submitted as a proposal for a State Wildlife Grant (SWG) in March 2014 (Appendix 5).

- Focal species should be selected for future research as a function of their conservation status (e.g., Covered Species in the San Diego Multiple Species Conservation Program and/or CDFW Species of Special Concern) and the potential impact of recreation activity on their occupancy, distribution, physiology, reproduction, or survival. Potential impact is a function of the combined sensitivity of species to human recreation and their exposure to recreational visitation in the NCCP reserves.
- The likely sensitivity of wildlife species to recreation use in NCCP reserves can be estimated from the results of prior studies documented in the systematic literature review. When no prior studies of similar species exist, we consider that species' sensitivity to recreation as 'unknown.' Results of the literature review indicate that mammal and bird species have been relatively well-studied, whereas the impacts of recreation on fish, reptiles, and amphibians are poorly known (Figure 1). Reptiles and amphibians were the two taxonomic groups for which the greatest proportion of studies observed a statistically significant effect of recreation (66-83%; Figure 4). Herpetofauna are likely to be vulnerable to disturbance because their habitats are also desirable destinations for humans, they are targets of illegal collectors (Buhlmann & Tuberville 1998), human activity is a source of direct mortality along roads and trails (Rochester et al. 2001), and because they are sensitive to displacement by competitor and predator species adapted to human activity (Spinks et al. 2003); however, it is important to note that there is substantial uncertainty around estimates of the relative sensitivity of reptiles and amphibians, because these were also taxa for which a relatively small number of studies have been completed. Among terrestrial mammal orders that occur in San Diego County, our literature review indicated that ungulates (51%) and bats (50%) were most frequently impacted by recreation activity (Figure 5a). The response of mid-sized to large mammal species to recreation has been examined in other California ecosystems, with species such as bobcats (*Felis rufus*) and coyotes (*Canis latrans*) exhibiting decreased abundance or temporal displacement in response to human activity (George & Crooks 2006, Reed & Merenlender 2008). One prior study in San Diego County demonstrated that

mountain lions (*Puma concolor*) were negatively associated with recreational biking, but did not include any reserves without public access or measure relative levels of visitation (Markovchick-Nicholls et al. 2008). Among avian orders, studies of shore and water birds (48-100%) most frequently observed a statistically significant effect (Figure 5b).

- Two types of studies are most needed to increase our understanding of the potential impacts of recreation on sensitive wildlife species and support adaptive management decisions: 1) Community-level studies of poorly-known taxonomic groups to identify individual species that are likely to be sensitive to human recreation; and 2) Experimental studies to identify causal mechanisms linking recreation activity to species occupancy, physiology, reproduction, or survival. In addition, where possible, we should seek opportunities to implement before-after control-impact (BACI) experiments where expansion or closure of trail networks is planned in NCCP reserves. These experiments would generate additional evidence regarding causal links between human activity and wildlife responses, relative to other known drivers of species distributions and will also provide an explicit test of management alternatives of opening, restricting, or NCCP closing reserves to public access.
- When designing a monitoring effort, the relative exposure to wildlife species can be estimated from the level of visitation among and within NCCP reserves, as measured by the expert opinion survey and pilot field study. These studies indicate that overall levels of recreation activity in the most-visited reserves are up to 100-110 times greater than in the least visited reserves (among those open to the public), and up to 48 times greater at the busiest staging areas than at the most remote trailheads (Figure 6, Table 4). Study sites and sampling points should be selected to maximize variation in the intensity of visitation within and among NCCP reserves. The pilot study indicated that visitation levels are highly variable by activity and among trails within a single reserve, and that factors influencing the variation in visitation (e.g., trailheads, accessibility, site amenities) differ among sites; thus, sampling points should be selected in a spatially-balanced random design throughout the interior of each site (Theobald et al. 2007). Additionally, unofficial or user-created trails comprise a mean of 45% of the trail networks of reserves mapped for the pilot study (range: 8-85%) and likely receive substantial human use; thus, sampling points should be located along both official and unofficial trails. If trail networks within a reserve selected as a study site are not available as a GIS data layer or were not previously mapped during the pilot study, then spatial data will need to be created via heads-up digitizing of trail features from aerial photography.
- Recreation monitoring should be designed to collect a continuous measure of recreation activity among trail segments, while accounting for variation among activity types and seasons. In the pilot study, we found that remotely-triggered cameras were the most efficient and cost-effective technique currently available for counting visitors to reserves (Table 3). Benefits of this sampling method include collecting a continuous, automated record of visitation by type of activity and direction of travel, as well as documenting concurrent wildlife activity in the area. Visitor counts from remotely-triggered cameras should be calibrated with timed visual observations, to estimate error rates and convert raw data into reliable visitation estimates (Pettebone et al. 2010). Two weeks of continuous sampling was sufficient to detect substantial variation in human visitation levels among trails and reserves in San Diego County, but longer sampling periods may be desirable if cameras are also used to detect rare wildlife species. Recreation monitoring should occur at regular intervals throughout the year to account for temporal variation in visitation levels. The large number of photos produced by monitoring with remotely-triggered cameras will require a strategy for sampling the dataset and classifying the photos according to number of visitors, type of recreation, and direction of travel. We recommend a sampling strategy that is proportionate to the frequency distribution of photos by time

of day, rather than a random or systematic sample, to ensure that photos are classified for times of day when visitors are most likely to be present. The resulting visitation data should be integrated into spatio-temporal models of recreation use intensity among trail segments, based on landscape features, accessibility, and site amenities.

- Statistical analyses should examine alternative possible use-impact relationships (Monz et al. 2013) between recreation activity and detection of the target species to assess: (1) the impact of recreation activity relative to other known drivers of species occupancy, distribution, physiology, reproduction and survival (e.g., habitat fragmentation, invasive species); and (2) the relative importance of individual recreation activities (e.g., hiking, mountain biking) and local characteristics on the occurrence, community composition, and relative abundance of sensitive species.

Communication and Next Steps

Over the course of the project, our research team made several trips to San Diego County to meet with Wildlife Agency staff and plan for different components of the research project:

- In November 2012, Sarah, Courtney, Kevin and Adina traveled to San Diego County. We presented our research plan and received feedback at the Coordination Meeting of the Wildlife Agencies, San Diego Management and Monitoring Program (SDMMP), and San Diego Association of Governments (SANDAG). We also toured potential field sites and met with prospective research collaborators (USGS, SDSU, etc.).
- In February 2013, Sarah, Courtney and Kevin traveled to San Diego County. We toured additional field sites and met with Ron Rempel regarding research design. We also met with land managers regarding research permits (e.g., City of San Diego, County of San Diego), and we requested feedback on questions for the expert opinion survey at the Coordination Meeting of the Wildlife Agencies, SDMMP, and SANDAG.
- In June 2013, Courtney relocated to San Diego County to implement the pilot field study, which continued until November 2013.
- In August 2013, Sarah and Kevin each traveled to San Diego County separately to help Courtney with final field site selection and sampling design.

In addition, to date our research team has made six presentations to communicate our progress on this project:

- Merenlender, A. M., C. L. Larson, S. E. Reed and K. R. Crooks. (March 2014) Review of the effects of recreation on wildlife. San Francisco Public Utilities Commission (SFPUC), San Francisco, CA.
- Larson, C. L., S. E. Reed, A. M. Merenlender and K. R. Crooks. (February 2014) A systematic review of the effects of recreation on wildlife. Front Range Student Ecology Symposium, Fort Collins, CO.
- Larson, C.L., S.E. Reed, A.M. Merenlender, and K.R. Crooks. (October 2013) Wildlife response to human recreation on NCCP reserves in San Diego County: project update. San Diego Management and Monitoring Program monthly coordination meeting, San Diego, CA.
- Reed, S. E. and S. L. Thomas. (November 2013) Balancing recreational access and conservation objectives in open space programs. The Next 40 Years: JeffCo Open Space Conservation, Golden, CO.
- Reed, S. E., S. L. Thomas, C. L. Larson, K. R. Crooks and A. M. Merenlender. (September 2013) Balancing public access with biodiversity protection: current knowledge and research priorities. Accessing Conservation Lands, Avoiding Environmental Conflicts, Berkeley, CA.
- Reed, S. E. (March 2013) Balancing public access with species protection: impacts of hiking, dogs, and motor vehicle noise on carnivores in California protected areas. New York State Department of Environmental Conservation (NYDEC), Raybrook, NY.

The project has generated substantial interest among the local collaborators, land and wildlife managers, and the scientific community. From the literature review as well as our conversations with the small number of other research groups that are actively engaged in recreation ecology research, it is clear that there is an urgent need for scientific information to support recreation designation and management decisions. This is especially

true for wildlife agencies in other states (e.g., NYDEC) and local resource managers in other areas of California (e.g., SFPUC), who are facing similar challenges associated with managing increasing levels of human visitation to reserve networks.

Moving forward, we plan to continue to analyze the data collected from the pilot field study, communicate the project's results in peer-reviewed journal articles and scientific presentations, and seek opportunities to implement the next phase of the study. Specifically, we will apply data collected in the pilot field study to construct a landscape-level spatio-temporal model of recreation use among NCCP reserves. The model will identify important predictors of the level of visitation to a reserve, including its accessibility (e.g., road density, number of trailheads, parking lots), landscape context (e.g., population density, vegetation, proximity to coast), site amenities (e.g., trail density, destinations, permitted activities), and other factors. The model can also be used to estimate levels of visitation in reserves not surveyed during the pilot field study. We will apply the landscape-level model to assess the potential impact to wildlife from recreation activity, by overlaying estimated recreation use at NCCP reserves with known locations of sensitive wildlife species (Appendix 4).

We will continue to communicate the project's findings in peer-reviewed journal articles and scientific presentations. Specifically, Courtney plans to submit at least two manuscripts on the project to scientific journals: one reporting results of the systematic literature review on recreation and wildlife (e.g., *Conservation Biology*), and one reporting results of the pilot field study and landscape-level model (e.g., *Landscape Ecology*). These articles will extend analyses of data collected for the project beyond the scope of the current agreement and provide a rigorous scientific basis the design of any future research and monitoring projects. We will share the resulting manuscripts with SDMMP and CDFW once they have been accepted for publication. In addition, Sarah has co-organized a symposium on recreation ecology and management at the 2014 North America Congress for Conservation Biology. The goals of the symposium are to explore the trade-offs and challenges of balancing public access with species protection in protected areas. Sarah will introduce the symposium and facilitate the discussion session, and Courtney will present the results of the landscape-level model during the symposium. Additional speakers will present projects from other areas of California (e.g., San Francisco Bay Area, Tejon Ranch) and other regions of North America. Participants and audience members will address the following questions: (1) What role should recreation play in the designation and management of protected areas?; (2) What are the most important gaps in our knowledge regarding recreation impacts?; and (3) What are our best options for managing the effects of recreation on biodiversity? Outcomes of this symposium will benefit management of recreation in San Diego County and elsewhere by encouraging increased coordination among researchers and resource managers throughout North America, catalyzing collaborations to support broad-scale empirical research on recreation ecology, and highlighting information needs and policy challenges associated with increasing human visitation to protected areas.

The planning phase of this project has yielded important information regarding the likely (or unknown) sensitivity of wildlife species to recreation and their relative exposure to recreation activity in NCCP reserves; thus, it provides a basis for selecting which wildlife species to study and which reserves to monitor in the next phase. It also generated recommendations for selecting survey techniques and designing sampling strategies for monitoring recreation activity. In the next 1-2 years, we plan to seek opportunities to implement a well-designed study that integrates species monitoring with recreation monitoring to systematically assess recreation's direct and indirect effects on sensitive wildlife species, to improve our understanding of the trade-offs inherent in multiple-use management of reserves, and to ensure that NCCP reserves are providing the required levels of protection and achieving the goals of the NCCP program.

Literature Cited

- Arlettaz, R., P. Patthey, M. Baltic, T. Leu, M. Schaub, R. Palme, and S. Jenni-Eiermann. 2007. Spreading free-riding snow sports represent a novel serious threat for wildlife. *Proceedings of the Royal Society B* 274:1219–1224.
- Balmford, A., J. Beresford, J. Green, R. Naidoo, M. Walpole and A. Manica. 2009. A global perspective on trends in nature-based tourism. *PLoS Biology* 7:e1000144.
- Banks, P. B., and J. V. Bryant. 2007. Four-legged friend or foe? Dog walking displaces native birds from natural areas. *Biology Letters* 3:611–613.
- Blumstein, D. T., E. Fernandez-Juricic, P. A. Zollner and S.C. Garity. 2005. Interspecific variation in avian responses to human disturbance. *Journal of Applied Ecology* 42:943-953.
- Boyle, S. A., and F. B. Samson. 1985. Effects of Nonconsumptive Recreation on Wildlife: A Review. *Wildlife Society Bulletin* 13:110–116.
- Buhlmann, K. A. and T. D. Tuberville. 1998. Use of passive integrated transponder (PIT) tags for marking small freshwater turtles. *Chelonian Conservation and Biology* 3:102-104.
- Cardoni, D. A., M. Favero, and J. P. Isacch. 2008. Recreational activities affecting the habitat use by birds in Pampa's wetlands, Argentina: Implications for waterbird conservation. *Biological Conservation* 141:797–806.
- Cessford, G., and A. Muhar. 2003. Monitoring options for visitor numbers in national parks and natural areas. *Journal for Nature Conservation* 11:240–250.
- Cordell, H. K. 2008. The Latest on Trends in Nature-Based Outdoor Recreation. *Forest History Today*:5.
- Czech, B., P. R. Krausman and P. K. Devers. 2000. Economic associations among causes of species endangerment in the United States. *BioScience* 50:593-601.
- Finney, S., J. Pearce-Higgins and D. Yalden. 2005. The effect of recreational disturbance on an upland breeding bird, the golden plover *Pluvialis apricaria*. *Biological Conservation* 121:53–63.
- Forrest, A. and C. C. St. Clair. 2006. Effects of dog leash laws and habitat type on avian and small mammal communities in urban parks. *Urban Ecosystems* 9:51-66.
- Frumkin, H. 2001. Beyond toxicity: human health and the natural environment. *American Journal of Preventative Medicine* 20:234-240.
- George, S. L. and K. R. Crooks. 2006. Recreation and large mammal activity in an urban nature reserve. *Biological Conservation* 133:107-117.
- Goodwin, H. J. 1996. In pursuit of ecotourism. *Biodiversity and Conservation* 5:277-291.
- Hadwen, W.L., W. Hill, and C.M. Pickering. 2007. Icons under threat: why monitoring visitors and their ecological impacts in protected areas matters. *Ecological Management & Restoration* 8:177-181.
- Knight, R. L., and D. N. Cole. 1995. *Wildlife and Recreationists: Coexistence through Management and Research*. Island Press, Washington, D.C.
- Liddle, M. 1997. *Recreation Ecology: The Ecological Impact of Outdoor Recreation*. Chapman & Hall, London, UK

- Liliehholm, R. J., and L. R. Romney. 2000. Tourism, national parks and wildlife. Pages 137–151 *Tourism and National Parks: Issues and Implications*. John Wiley & Sons, Inc., New York.
- Liu, J., M. Linderman, Z. Ouyang, L. An, J. Yang and H. Zhang. 2001. Ecological degradation in protected areas: the case of Wolong Nature Reserve for giant pandas. *Science* 292:98-101.
- Losos, E., J. Hayes, A. Phillips, D. Wilcove, and C. Alkire. 1995. Taxpayer-Subsidized Resource Extraction Harms Species. *BioScience* 45:446–455.
- Markovchick-Nicholls, H. M. Regan, D. H. Deutschman, A. Widyanata, B. Martin, L. Noreke and T. A. Hunt. 2008. Relationships between human disturbance and wildlife land use in urban habitat fragments. *Conservation Biology* 22:99-109.
- Martínez-Abraín, A., D. Oro, J. Jiménez, G. Stewart, and A. Pullin. 2010. A systematic review of the effects of recreational activities on nesting birds of prey. *Basic and Applied Ecology* 11:312–319.
- Marzano, M., and N. Dandy. 2012. Recreationist behaviour in forests and the disturbance of wildlife. *Biodiversity and Conservation* 21:2967–2986.
- McClaran, M. P., and D. N. Cole. 1993. Packstock in wilderness: use, impacts, monitoring, and management. US Department of Agriculture, Forest Service, Intermountain Research Station.
- Monz, C. A., C. M. Pickering and W. L. Hadwen. 2013. Recent advances in recreation ecology and the implications of different relationships between recreation use and ecological impacts. *Frontiers in Ecology and the Environment* 11: 441-446.
- Newsome, D., S. A. Moore, and R. K. Dowling. 2013. *Natural Area Tourism: Ecology, Impacts, and Management*, 2nd edition. Channel View Publications, Bristol.
- Orams, M. B. 2002. Feeding wildlife as a tourism attraction: a review of issues and impacts. *Tourism Management* 23:281–293.
- Pettebone, D., P. Newman, and S. R. Lawson. 2010. Estimating visitor use at attraction sites and trailheads in Yosemite National Park using automated visitor counters. *Landscape and Urban Planning* 97:229–238.
- Pullin, A. S., and G. B. Stewart. 2006. Guidelines for Systematic Review in Conservation and Environmental Management. *Conservation Biology* 20:1647–1656.
- Reed, S. E., and A. M. Merenlender. 2008. Quiet, Nonconsumptive Recreation Reduces Protected Area Effectiveness. *Conservation Letters* 1:146–154.
- Rochester, C., S. Hathaway, C. Brown, K. Pease and R. Fisher. 2001. Herpetofaunal monitoring in MSCP region of San Diego. U.S. Geological Survey, San Diego, CA.
- Rogala, J. K., M. Hebblewhite, J. Whittington, C. A. White, J. Coleshill, and M. Musiani. 2011. Human Activity Differentially Redistributes Large Mammals in the Canadian Rockies National Parks. *Ecology and Society* 16:16.
- Spinks, P. Q., G. B. Pauly, J. J. Crayon and H. B. Shaffer. 2003. Survival of the western pond turtle (*Emys marmorata*) in an urban California environment. *Biological Conservation* 113:257-267.
- Stankowich, T. 2008. Ungulate flight responses to human disturbance: A review and meta-analysis. *Biological Conservation* 141:2159–2173.

- Steven, R., C. Pickering, and J. G. Castley. 2011. A review of the impacts of nature based recreation on birds. *Journal of Environmental Management* 92:2287–2294.
- Taylor, A. R. and R. L. Knight. 2003. Wildlife responses to recreation and associated visitor perceptions. *Ecological Applications* 13:951-963
- Theobald, D. M., D. L. Stevens, Jr., D. White, N. S. Urquhart, A. R. Olsen and J. B. Norman, 2007. Using GIS to generate spatially-balanced random survey designs for natural resource applications. *Environmental Management* 40:134-146.
- Watson, A. E., D. N. Cole, D. L. Turner, and P. S. Reynolds. 2000. *Wilderness recreation use estimation: a handbook of methods and systems*. U.S. Department of Agriculture, Ogden, UT.
- Wolfe, S. A., B. Griffith, and C. A. G. Wolfe. 2000. Response of reindeer and caribou to human activities. *Polar Research* 19:63–73.
- Zaradic, P.A., O.R.W. Pergams, and P. Kareiva. 2009. The impact of nature experience on willingness to support conservation. *PLoS One* 4:e7367.

Appendix 1. Bibliography of peer-reviewed journal articles included in the systematic literature review, including abstracts and keywords.

Amo, L., P. López, and J. Martín. 2006. Nature-based tourism as a form of predation risk affects body condition and health state of *Podarcis muralis* lizards. *Biological Conservation* **131**:402–409.

Nature-based tourism has experienced a greater increase, and, even although it might have deleterious effects for many wildlife species, its consequences remains little explored. Many lizard species are endangered and tourism has been proposed as a potential factor responsible of the decline of several lizards' populations, but no study has examined the effect of tourism on lizards' behaviour, body condition and health state. Many lizards respond to people as if they were predators, by readily escaping to refuges. However, an increase in the frequency of these antipredatory strategies can lead to a loss of body condition, which may have important consequences for short and long term fitness. We analysed the effects of tourism on escape behaviour of common wall lizards, *Podarcis muralis*, as well as on their body condition and health state (ectoparasites, blood parasites, and cell mediated immune response). Results showed that lizards did not modify their escape behaviour in response to tourism. Lizards had similar approach and flight distances, and escape strategies regardless of the level of tourism pressure. However, lizards inhabiting areas with high tourism levels, where they presumably needed to perform antipredatory behaviours more often, showed higher intensity of infection by ticks and lower body condition at the end of the breeding period. Moreover, lizards with poorer body condition had lower cell mediated immune responses. Therefore, tourism seems to have deleterious effects on body condition and on host–parasite relationships in this lizard species. These effects should be taking into account when designing walking paths in protected areas. Our study reports evidence that regardless lizards showed similar escape behaviour in tourist than in natural areas, their body condition and health state should be also examined to accurately assess the actual effects of tourism on lizards' populations.

Keywords: reptile, Spain, forest, hiking

Arlettaz, R., P. Patthey, M. Baltic, T. Leu, M. Schaub, R. Palme, and S. Jenni-Eiermann. 2007. Spreading Free-Riding Snow Sports Represent a Novel Serious Threat for Wildlife. *Proceedings: Biological Sciences* **274**:1219–1224.

Stress generated by humans on wildlife by continuous development of outdoor recreational activities is of increasing concern for biodiversity conservation. Human disturbance often adds to other negative impact factors affecting the dynamics of vulnerable populations. It is not known to which extent the rapidly spreading free-riding snow sports actually elicit detrimental stress (allostatic overload) upon wildlife, nor what the potential associated fitness and survival costs are. Using a non-invasive technique, we evaluated the physiological stress response induced by free-riding snow sports on a declining bird species of Alpine ecosystems. The results of a field experiment in which radiomonitored black grouse (*Tetrao tetrix*) were actively flushed from their snow burrows once a day during four consecutive days showed an increase in the concentration of faecal stress hormone (corticosterone) metabolites after disturbance. A large-scale comparative analysis across the southwestern Swiss Alps indicated that birds had higher levels of these metabolites in human-disturbed versus undisturbed habitats. Disturbance by snow sport free-riders appears to elevate stress, which potentially represents a new serious threat for wildlife. The fitness and survival costs of allostatic adjustments have yet to be estimated.

Keywords: bird, Switzerland, forest, alpine ski/snowboard

Ayres, E., J. N. Nkem, D. H. Wall, B. J. Adams, J. E. Barrett, E. J. Broos, A. N. Parsons, L. E. Powers, B. L. Simmons, and R. A. Virginia. 2008. Effects of human trampling on populations of soil fauna in the McMurdo dry valleys, Antarctica. *Conservation Biology* **22**:1544–1551.

Antarctic ecosystems are often considered nearly pristine because levels of anthropogenic disturbance are extremely low there. Nevertheless, over recent decades there has been a rapid increase in the number of people, researchers and tourists, visiting Antarctica. We evaluated, over 10 years, the direct impact of foot traffic on the abundance of soil animals and soil properties in Taylor Valley within the McMurdo Dry Valleys region of Antarctica. We compared soils from minimally disturbed areas with soils from nearby paths that received intermediate and high levels of human foot traffic (i.e., up to approximately 80 passes per year). The nematodes *Scottinema lindsayae* and *Eudorylaimus* sp. were the most commonly found animal species, whereas rotifers and tardigrades were found only occasionally. On the highly trampled footpaths, abundance of *S. lindsayae* and *Eudorylaimus* sp. was up to 52 and 76% lower, respectively, than in untrampled areas. Moreover, reduction in *S. lindsayae* abundance was more pronounced after 10 years than 2 years and in the surface soil than in the deeper soil, presumably because of the longer period of disturbance and the greater level of physical disturbance experienced by the surface soil. The ratio of living to dead *Eudorylaimus* sp. also declined with increased trampling intensity, which is indicative of increased mortality or reduced fecundity. At one site there was evidence that high levels of trampling reduced soil CO₂ fluxes, which is related to total biological activity in the soil. Our results show that even low levels of human traffic can significantly affect soil biota in this ecosystem and may alter ecosystem processes, such as carbon cycling. Consequently, management and conservation plans for Antarctic soils should consider the high sensitivity of soil fauna to physical disturbance as human presence in this ecosystem increases.

Keywords: invertebrate, Antarctica, polar, hiking

Banks, P. B., and J. V. Bryant. 2007. Four-legged friend or foe? Dog walking displaces native birds from natural areas. *Biology Letters* **3**:611–613.

Dog walking is among the world's most popular recreational activities, attracting millions of people to natural areas each year with diverse benefits to human and canine health. But conservation managers often ban dog walking from natural areas fearing that wildlife will see dogs as potential predators and abandon their natural habitats, resulting in outcry at the restricted access to public land. Arguments are passionate on both sides and debate has remained subjective and unresolved because experimental evidence of the ecological impacts of dog walking has been lacking. Here we show that dog walking in woodland leads to a 35% reduction in bird diversity and 41% reduction in abundance, both in areas where dog walking is common and where dogs are prohibited. These results argue against access by dog walkers to sensitive conservation areas.

Keywords: bird, Australia, forest, hiking, dog-walking

Barros, F. 2001. Ghost crabs as a tool for rapid assessment of human impacts on exposed sandy beaches. *Biological Conservation* **97**:399–404.

On exposed sandy beaches, the destruction of sand dunes and intense recreational activities are often the most common anthropogenic disturbances. It was proposed that such disturbances should have important effects on animals such as ghost crabs. Numbers of burrows of ghost crabs, *Ocypode cordimana*, were compared

between urban and non-urban beaches at different levels on the shore. Overall, there were more burrows at high levels near sand dunes. There were significantly fewer burrows at high levels on urban than on non-urban beaches. These differences are discussed in terms of destruction of habitat and possible changes in behaviour of crabs. This study suggests that the world-wide genus *Ocypode* may be useful as a tool in rapid assessment of human impacts on exposed sandy beaches.

Keywords: invertebrate, Australia, beach, beach use

Baudains, T. P., and P. Lloyd. 2007. Habituation and habitat changes can moderate the impacts of human disturbance on shorebird breeding performance. *Animal Conservation* **10**:400–407.

Disturbance by humans is widely expected to reduce the reproductive fitness of nesting birds if disturbance reduces nest attentiveness, and unattended eggs experience increased risk of predation or exposure to potentially lethal temperature extremes. Yet, relatively few studies have examined the physiological or behavioural mechanisms whereby disturbance influences reproductive fitness, or the extent to which the costs of disturbance may be reduced through habituation. We compared the behavioural responses, egg temperatures and reproductive success of shore-nesting white-fronted plovers *Charadrius marginatus* to disturbance at two breeding sites experiencing low versus high human recreational activity, respectively. Daytime nest attentiveness decreased with increasing experimental disturbance at both sites, but this relationship differed between sites; for any given level of disturbance, incubating birds at the more disturbed site had greater nest attentiveness. They achieved this through habituation, allowing a closer human approach before leaving the nest, and returning to the nest faster after a disturbance event. Despite lower average daytime nest attentiveness at the more disturbed site, incubation temperatures did not differ significantly between sites. Nest mortality, mostly by natural mammalian and corvid predators, was significantly lower at the site experiencing high recreational activity. However, chick mortality was significantly greater at the more disturbed site, most likely because of predation by domestic dogs. Chick mortality may have been increased by the habituation of chicks, whose escape responses were much reduced at the more disturbed site. Nonetheless, annual fecundity was substantially higher at the more disturbed site, showing that the overall reproductive fitness of wild birds is not always compromised by human disturbance and urbanization.

Keywords: bird, South Africa, beach, beach use, dog-walking

Beale, C. M., and P. Monaghan. 2005. Modeling the effects of limiting the number of visitors on failure rates of seabird nests. *Conservation Biology* **19**:2015–2019.

Abstract: Most attempts to manage disturbance by visitors to nature reserves concentrate on limiting visitor access in some way, which is often unpopular with both visitors and managers. In a few nature reserves the daily numbers of visitors are limited, an action that need not necessarily reduce the total number of visitors. As a test of the assumptions that underlie this management practice, we examined the relationship between daily visitor numbers and daily failure rates of nests in two species of seabirds. Daily failure rates for Black-legged Kittiwakes (*Rissa tridactyla*) were weakly correlated with daily visitor numbers but indicated that capping daily visitor numbers slightly reduced overall breeding success. This was not the case for Common Murres (*Uria aalge*), where failure rate declined seasonally but was not significantly correlated with visitor numbers. For some species, it appears that capping daily visitor numbers may have small conservation costs.

Keywords: bird, United Kingdom, shoreline, hiking

Behie, A. M., M. S. M. Pavelka, and C. A. Chapman. 2010. Sources of variation in fecal cortisol levels in howler monkeys in Belize. *American journal of primatology* **72**:600–606.

High cortisol levels are known to cause low fecundity and increased mortality; thus, the prospect of using cortisol as a measure of population health is an exciting one. However, because so many factors can interact to influence cortisol release, it can be difficult to interpret what exactly is creating changes to cortisol levels. This study investigates variation in fecal cortisol levels in a population of black howlers (*Alouatta pigra*) from 350 fecal samples collected from 33 individuals in more than 4 years. A general linear mixed model revealed that cortisol varied significantly with fruit availability and contact with tourists. When fruit availability was low, cortisol increased, likely because when fruit availability is low monkeys eat less fruit, thus obtaining less sugar. This result may simply reflect cortisol's metabolic function of mobilizing glucose. It also indicates that these monkeys may be experiencing periods of food stress throughout the year, which was earlier thought to be minimal for a primarily folivorous species. Presence of tourists was the only other factor found to lead to high cortisol; with exposure to tourists increasing stress levels. These results highlight the importance of understanding how physiological factors can influence cortisol, making it easier to interpret results and determine the external social or ecological stressors that may increase cortisol.

Keywords: mammal, Belize, forest, hiking

Bejder, L., S. M. Dawson, and J. A. Harraway. 1999. Responses by Hector's Dolphins to Boats and Swimmers in Porpoise Bay, New Zealand. *Marine Mammal Science* **15**:738–750.

Theodolite tracking (61 d; 251 h) was used to quantify dolphin reactions to boats and swimmers in the austral summers of 1995-1996 and 1996-1997. Dolphins were accompanied by swimmers (within 200 m) for 11.2% of the total observation time, whereas boats accounted for an additional 12.4%. Dolphins were not displaced by either of these activities. Swimmers caused only weak, non-significant effects, perhaps because dolphins could very easily avoid them. Reactions to the dolphin-watching boat were stronger. Analyses of relative orientation indicate that dolphins tended to approach the vessel in the initial stages of an encounter but became less interested as the encounter progressed. By 70 min into an encounter dolphins were either actively avoiding the boat or equivocal towards it, approaching significantly less often than would be expected by chance. Analyses of group dispersion indicate that dolphins were significantly more tightly bunched when a boat was in the bay.

Keywords: mammal, New Zealand, marine, wildlife viewing (boat), swimming/diving

Bejder, L., A. Samuels, H. Whitehead, and N. Gales. 2006a. Interpreting short-term behavioural responses to disturbance within a longitudinal perspective. *Animal Behaviour* **72**:1149–1158.

We documented immediate, behavioural responses of Indo-Pacific bottlenose dolphins (*Tursiops* sp.) to experimental vessel approaches in regions of high and low vessel traffic in Shark Bay, Western Australia. Experimental vessel approaches elicited significant changes in the behaviour of targeted dolphins when compared with their behaviour before and after approaches. During approaches, focal dolphin groups became more compact, had higher rates of change in membership and had more erratic speeds and directions of travel. Dolphins in the region of low vessel traffic (control site) had stronger and longer-lasting responses than did dolphins in the region of high vessel traffic (impact site). In the absence of additional information, the

moderated behavioural responses of impact-site dolphins probably would be interpreted to mean that long-term vessel activity within a region of tourism had no detrimental effect on resident dolphins. However, another study showed that dolphin-watching tourism in Shark Bay has contributed to a long-term decline in dolphin abundance within the impact site (Bejder et al., in press, *Conservation Biology*). Those findings suggest that we documented moderated responses not because impact-site dolphins had become habituated to vessels but because those individuals that were sensitive to vessel disturbance left the region before our study began. This reinterpretation of our findings led us to question the traditional premise that short-term behavioural responses are sufficient indicators of impacts of anthropogenic disturbance on wildlife.

Keywords: mammal, Australia, marine, wildlife viewing (boat)

Bejder, L., A. Samuels, H. Whitehead, N. Gales, J. Mann, R. Connor, M. Heithaus, J. Watson-Capps, C. Flaherty, and M. Krützen. 2006b. Decline in relative abundance of bottlenose dolphins exposed to long-term disturbance. *Conservation Biology* **20**:1791–1798.

Studies evaluating effects of human activity on wildlife typically emphasize short-term behavioral responses from which it is difficult to infer biological significance or formulate plans to mitigate harmful impacts. Based on decades of detailed behavioral records, we evaluated long-term impacts of vessel activity on bottlenose dolphins (*Tursiops* sp.) in Shark Bay, Australia. We compared dolphin abundance within adjacent 36-km² tourism and control sites, over three consecutive 4.5-year periods wherein research activity was relatively constant but tourism levels increased from zero, to one, to two dolphin-watching operators. A nonlinear logistic model demonstrated that there was no difference in dolphin abundance between periods with no tourism and periods in which one operator offered tours. As the number of tour operators increased to two, there was a significant average decline in dolphin abundance (14.9%; 95% CI = -20.8 to -8.23), approximating a decline of one per seven individuals. Concurrently, within the control site, the average increase in dolphin abundance was not significant (8.5%; 95% CI = -4.0 to +16.7). Given the substantially greater presence and proximity of tour vessels to dolphins relative to research vessels, tour-vessel activity contributed more to declining dolphin numbers within the tourism site than research vessels. Although this trend may not jeopardize the large, genetically diverse dolphin population of Shark Bay, the decline is unlikely to be sustainable for local dolphin tourism. A similar decline would be devastating for small, closed, resident, or endangered cetacean populations. The substantial effect of tour vessels on dolphin abundance in a region of low-level tourism calls into question the presumption that dolphin-watching tourism is benign.

Keywords: mammal, Australia, marine, wildlife viewing (boat)

Berman, C. M., J. Li, H. Ogawa, C. Ionica, and H. Yin. 2007. Primate tourism, range restriction, and infant risk among *Macaca thibetana* at Mt. Huangshan, China. *International Journal of Primatology* **28**:1123–1141.

An increased number of tourists viewing animals in the wild have increased stress on these animals (hereafter wildlife). Many wildlife-viewing locations rely on voluntary compliance with posted regulations to protect animals from tourists because of the expense of employing on-site enforcement personnel. Voluntary compliance, however, is ineffective. The presence of official-looking volunteers may decrease the incidence of wildlife harassment by tourists. To test this possibility, we observed tourists interacting with 5- to 12-month-old New Zealand fur seals (*Arctocephalus forsteri*) at the popular Ohau Stream waterfall while in the absence or presence of a young woman in plain sight wearing a neon vest (i.e., observer) and when an observer was not

present. We observed 254 tourist groups at the waterfall when young seals were present. The percentage of groups in which at least one person harassed (approached, touched, or threw objects) a young seal was two-thirds lower when the official-looking observer was present. Frequency of harassment was inversely related to observer presence. Programs in which volunteers work at tourist sites are popular in countries with high tourism rates, such as New Zealand. Our results show that a relatively inexpensive and effective tourism-management strategy may be to post such volunteers as observers at sites where tourists view wildlife.

Keywords: mammal, China, forest, wildlife viewing (land)

Bishop, M. J. 2008. Displacement of epifauna from seagrass blades by boat wake. *Journal of Experimental Marine Biology and Ecology* **354**:111–118.

Due to the increasing accessibility of waterways under coastal development, recreational boating is among the growing disturbances to seagrasses at the local scale. While previous studies indicate that in decreasing and fragmenting seagrass habitat, boating can impact the diverse faunal assemblages associated with this habitat, direct impacts of boat wake on phytoplankton invertebrates have not been assessed. By sampling seagrass blades twice before, immediately after and 1 h after exposure to recreational boat wake, this study documented the displacement of macroinvertebrates from flapping seagrass blades. At wake-exposed sites, up to five-fold decreases in the total abundances of amphipods and polychaetes and two-fold decreases in taxon richness were evident from immediately before to immediately after the disturbance of wake. By contrast, at control sites, the abundance and richness of these taxa remained fairly unchanged during the study and in some cases even increased. Although many of the displaced taxa were mobile, additional sampling indicated that they did not completely recolonize seagrass patches within 1 h of the disturbance. Thus, in places where boat traffic is relatively frequent, permanent depression of abundances of macroinvertebrates in seagrass may occur. This is of concern given that macroinvertebrates fuel fisheries productivity. Thus, in areas with frequent and or intense boating activity, nursery functions of seagrass beds may be severely compromised.

Keywords: invertebrate, Australia, wetland, motorized (boat)

Blom, A., C. Cipolletta, A. M. H. Brunsting, and H. H. T. Prins. 2004. Behavioral responses of gorillas to habituation in the Dzanga-Ndoki National Park, Central African Republic. *International Journal of Primatology* **25**:179–196.

We monitored the impact of habituation for tourism through changes in gorillas' behavior during the habituation process at Bai Hokou (Dzanga-Ndoki National Park, Central African Republic) from August 1996 to December 1999. From August 1998 onwards we focused on one gorilla group: the Munye. During the habituation process, it became increasingly easier to locate and to remain with the gorillas. Their initial reactions of aggression, fear and vocalization upon contact were replaced increasingly by ignoring us. Curiosity appeared to be an intermediate stage in the process. The way in which contacts with the Munye ended became more subdued over time. Regular daily contact is important in promoting habituation. Likewise, contacting gorillas while they are in a tree or in dense forest provides positive results compared to open habitat. Contacts within 10 m and contacts without forewarning the gorillas of observer presence, e.g., via tongue clacking, should be avoided. As of December 1999, habituation had progressed well; habituation of western gorillas is feasible. However, the gorillas experience negative effects during the habituation process, showing, for example, an increase in daily path length, and reactions of aggression, fear and vocalization upon

contact. Impacts diminish over time. Given these and other potentially negative effects, the decision to begin habituation should not be taken lightly.

Keywords: mammal, Central African Republic, forest, wildlife viewing (land)

Bolduc, F., and M. Guillemette. 2003. Human disturbance and nesting success of Common Eiders: interaction between visitors and gulls. *Biological Conservation* **110**:77–83.

Common Eider colonies often are subjected to human visitors, such as down collectors, recreationists and researchers. However, the effects of frequency and timing of disturbance, and the abundance of nearby avian predators on eider nesting success have been studied only partly. We used three experimental treatments and six eider colonies over 3 years (1993–1995) to test the effects of these factors on eider nesting success, while controlling results for associated gull nest density. Treatments consisted of (1) high frequency visits (once every 3 days) starting early in the incubation period (HFE), (2) low frequency visits (once every 15 days) starting early in the incubation period (LFE), and (3) high frequency visits starting late in the incubation period (HFL). Analysis of covariance indicated that both disturbance treatments and associated gull nest density had a significant effect on eider nesting success probability. Nesting success probabilities were similar for eiders under HFE and LFE treatments (means=0.317±0.166 [SE] and 0.434±0.172 respectively), indicating that changes in frequency of visits had little impact on nesting success. In contrast, timing of visits had a major influence on nesting success, as the HFL treatment resulted in a significant higher nesting success probability (mean=0.981±0.191) than the HFE treatment. Most nest failures occurred after the first visit in all treatments, although the impact of the first visit was lowest in the HFL treatment. Researchers and wildlife managers should visit eider colonies as late as possible, and avoid visiting colonies associated with high densities of eider egg predators.

Keywords: bird, Canada, forest, grassland, hiking

Borkowski, J. 2001. Flight behaviour and observability in human-disturbed sika deer. *Acta Theriologica* **46**:195–206.

Sika deer (*Cervus nippon* Temminck, 1838) observability and flight behaviour were studied in an area with a high level of human disturbance (Tanzawa Mts, Japan). Deer observation rate was positively affected by habitat-related food conditions, while it was negatively correlated with the number of tourists in the study area. Flight frequency in April-September was lower than in October-February. It was also influenced by period of day, behaviour of investigator and deer group size. Group composition, deer activity and habitat condition had no effect on flight frequency. Thus, only 317 (48%) of the deer groups encountered were caused to flee and among them as many as 86% fled for a distance shorter than 40 m. It was concluded that deer in Tanzawa Mts learned to tolerate people, what is known for the populations which are unhunted or under low hunting pressure.

Keywords: mammal, Japan, forest, hiking

Borkowski, J. J., P. J. White, R. A. Garrott, T. Davis, A. R. Hardy, and D. J. Reinhart. 2006. Behavioral responses of bison and elk in Yellowstone to snowmobiles and snow coaches. *Ecological Applications* **16**:1911–1925.

Managers of public lands are charged with protecting some of our most important natural resources and ecosystems, while providing for their use and enjoyment by visitors. Almost one million visitors entered Yellowstone National Park by motorized means on snowmobiles (87%) or snow coaches (13%) during 1992–2003. Most vehicles toured the central portion of the park where bison (*Bison bison*) and elk (*Cervus elaphus*) concentrate in geothermal areas. We sampled >6500 interactions between groups of these species and groups of snowmobiles and snow coaches (collectively, OSV, over-snow vehicles) during five winters (1999–2000, 2002–2004). Multinomial logits models were used to identify conditions leading to behavioral responses. Elk responded three times as often (52%) as bison (19%) during interactions with groups of snowmobiles and snow coaches due to increased vigilance responses (elk, 44%; bison, 10%). However, the frequency of higher-intensity movement responses by bison and elk were similar (6–7% travel, 1–2% flight, <1% defense) and relatively low compared to other studies of ungulates and snowmobile disturbance. The likelihood of active responses by bison and elk increased significantly if animals were on or near roads, groups were smaller, or humans approached. The likelihood of an active response by bison decreased within winters having the largest visitation, suggesting some habituation to snowmobiles and snow coaches. There was no evidence that snowmobile use during the past 35 years affected the population dynamics or demography of bison or elk. Thus, we suggest that regulations restricting levels and travel routes of over-snow vehicles (OSVs) were effective at reducing disturbances to bison and elk below a level that would cause measurable fitness effects. We recommend park managers consider maintaining OSV traffic levels at or below those observed during our study. Regardless, differing interpretations of the behavioral and physiological response data will continue to exist because of the diverse values and beliefs of the many constituencies of Yellowstone.

Keywords: mammal, United States, forest, grassland, motorized (land)

Bowen, K. D., and F. J. Janzen. 2008. Human Recreation and the Nesting Ecology of a Freshwater Turtle (*Chrysemys picta*). *Chelonian Conservation and Biology* 7:95–100.

Over a 3-year period, we studied the relationship between the intensity of human recreation and the nesting ecology of the painted turtle (*Chrysemys picta*) at a major nesting beach. Our results suggest that the intensity of human recreation at this site had no effect on the decision of turtles to emerge from the water and nest, or on habitat selection by nesting turtles. This apparent lack of effect of human recreation is contrary to the results of many previously published studies on other taxa and underscores the variability in wildlife responses to human recreation and the need for species-specific and population-specific studies.

Keywords: reptile, United States, beach, motorized (land)

Braunisch, V., P. Patthey, and R. Arlettaz. 2011. Spatially explicit modeling of conflict zones between wildlife and snow sports: prioritizing areas for winter refuges. *Ecological Applications* 21:955–967.

Outdoor winter recreation exerts an increasing pressure upon mountain ecosystems, with unpredictable, free-ranging activities (e.g., ski mountaineering, snowboarding, and snowshoeing) representing a major source of stress for wildlife. Mitigating anthropogenic disturbance requires the spatially explicit prediction of the interference between the activities of humans and wildlife. We applied spatial modeling to localize conflict zones between wintering Black Grouse (*Tetrao tetrix*), a declining species of Alpine timberline ecosystems, and two free-ranging winter sports (off-piste skiing [including snow-boarding] and snowshoeing). Track data (snow-sports and birds' traces) obtained from aerial photographs taken over a 585-km transect running along the timberline, implemented within a maximum entropy model, were used to predict the occurrence of snow

sports and Black Grouse as a function of landscape characteristics. By modeling Black Grouse presence in the theoretical absence of free-ranging activities and ski infrastructure, we first estimated the amount of habitat reduction caused by these two factors. The models were then extrapolated to the altitudinal range occupied by Black Grouse, while the spatial extent and intensity of potential conflict were assessed by calculating the probability of human-wildlife co-occurrence. The two snow-sports showed different distribution patterns. Skiers' occurrence was mainly determined by ski-lift presence and a smooth terrain, while snowshoers' occurrence was linked to hiking or skiing routes and moderate slopes. Wintering Black Grouse avoided ski lifts and areas frequented by free-ranging snow sports. According to the models, Black Grouse have faced a substantial reduction of suitable wintering habitat along the timberline transect: 12% due to ski infrastructure and another 16% when adding free-ranging activities. Extrapolating the models over the whole study area results in an overall habitat loss due to ski infrastructure of 10%, while there was a > 10% probability of human-wildlife encounters on 67% of the remaining area of suitable wintering habitat. Only 23% of the wintering habitat was thus free of anthropogenic disturbance. By identifying zones of potential conflict, while rating its relative intensity, our model provides a powerful tool to delineate and prioritize areas where wildlife winter refuges and visitor steering measures should be implemented.

Keywords: bird, Switzerland, forest, alpine ski/snowboard

Bright, A., G. R. Reynolds, J. Innes, and J. R. Waas. 2003. Effects of motorised boat passes on the time budgets of New Zealand dabchick, *Poliiocephalus rufopectus*. *Wildlife Research* **30**:237–244.

New Zealand dabchicks, *Poliiocephalus rufopectus*, are small grebes restricted to the North Island of New Zealand; with a total population of only ~1200-1500 birds, they are classed as endangered. We conducted experiments to examine the effects of boat passes of different speeds and frequencies on the time budgets of the New Zealand dabchick. We also examined whether New Zealand dabchicks became habituated to boat passes. We found that a single boat pass caused a significant short-term change in New Zealand dabchick behaviour compared with pre-boat pass patterns. This change in behaviour was more pronounced when the frequency of boat passes was higher, and may impose energetic constraints on New Zealand dabchicks. Differences between behaviour before and after the boat pass were no longer evident 15 minutes after the boat pass. We found no significant effects of boat speed (5 v. 10 knots) on the behaviour of New Zealand dabchicks. There was evidence of habituation to boat traffic in high-use recreational sites. Further studies are required to investigate the influence of other human activities and the influence that boat and wave wash have on the nesting and breeding success of the New Zealand dabchick.

Keywords: bird, New Zealand, freshwater, shoreline, motorized (boat)

Bright, A., J. R. Waas, and J. Innes. 2004. Correlations between human-made structures, boat-pass frequency and the number of New Zealand dabchicks (*Poliiocephalus rufopectus*) on the Rotorua Lakes, New Zealand. *New Zealand Journal of Ecology* **28**:137–142.

Negative effects of human presence and activities on breeding success and survival of many water bird species are well documented. The New Zealand dabchick (*Poliiocephalus rufopectus*) is a protected endemic New Zealand grebe, confined to the North Island mainland and classified as vulnerable. A third of the total New Zealand dabchick population live on the lakes of the central volcanic plateau, where there is potential conflict between humans and dabchicks. We used data from two independent surveys describing the distribution of New Zealand dabchicks to investigate the effect that human-made structures (i.e. jetties and houses) and

human recreational activities (i.e. boating) have on the numbers of New Zealand dabchick pairs, chicks and nests in the bays of Lake Rotoiti, Tarawera and Okareka. Our results suggest that human-made structures and recreational activities are not significantly affecting the numbers and distribution of New Zealand dabchick pairs or nests at this time. Furthermore, the number of human-made structures was positively correlated with the number of chicks in the sampled bays. Humans and dabchicks may be distributed similarly around the lakes because factors such as wind exposure and shoreline topography made certain sites preferable for both species. Alternatively, human-made structures may provide protected nesting environments and/or cover for chicks from predators, refuges from harassment by other bird species, or other benefits. Pairs may therefore be able to raise chicks to the fledging stage more successfully. However, little is currently known about dabchick life history or population dynamics. We recommend that a method of capturing and marking be developed so that further monitoring of behavioural and population changes can be carried out. It is also necessary to conduct research on how boats and human activities at jetties affect incubating dabchicks and their young during the nesting phase.

Keywords: bird, New Zealand, freshwater, shoreline, motorized (boat)

Burger, J., and M. Gochfeld. 2007. Responses of Emperor Penguins (*Aptenodytes forsteri*) to encounters with ecotourists while commuting to and from their breeding colony. *Polar Biology* **30**:1303–1313.

Emperor penguins (*Aptenodytes forsteri*) were studied at the Snow Hill breeding colony in November 2006 to determine the effect of people on penguins traveling between the colony and the sea to forage. We tested the null hypothesis that the presence and number of people had no effect on the trajectory of movement or the number and duration of pauses. The distances at which penguins noticed people (mean 35.6 m), changed direction (mean 22.8 m), and the number and duration of pauses increased significantly with increases in the number of tourists in their path, which explained more than 50% of the variance. Undisturbed penguins usually tobogganed on their ventral surface over the ice. When penguins noticed people, they usually stood up and often called. In 10 min observation periods, penguins traveling more than 200 m from people paused an average of <1 min vs. 3.8 min for those passing near people, increasing the energetic cost of commuting. After passing people, penguins rarely stopped. Penguins response to people varied by time of day; later in the day they responded less quickly, changed directions when closer to people, stopped for less time, and passed by people closer than they did earlier in the day. We suggest that the effect of ecotourists on traveling penguins can be partly mitigated by having people walk in small, tight-knit groups, by having people stop moving whenever traveling penguins are within about 25 m to allow the penguins to choose the direction of their passage, and by keeping the visitor pathway separate from the penguin paths insofar as possible.

Keywords: bird, Antarctica, polar, hiking, wildlife viewing (land)

Burger, J., M. Gochfeld, C. D. Jenkins, and F. Lesser. 2009. Effect of Approaching Boats on Nesting Black Skimmers: Using Response Distances to Establish Protective Buffer Zones. *Journal of Wildlife Management* **74**:102–108.

Understanding how birds respond to the activities of people is an important component of conserving wildlife. We measured responses of nesting black skimmers (*Rynchops niger*) to an approaching boat in Barnegat Bay, New Jersey, USA, by examining distance to first respond, distance to flush, and time to return to the colony. Our objective was to determine if response distances of skimmers changed as a function of year, reproductive stage, direction of approach (direct or tangential), or number of birds nesting in the colony.

Generally, reproductive stage had the greatest effect on all responses, followed by direction of approach, number of adults present at the colony, number of nests, and year, which also explained variation in behavioral responses. The distance at which skimmers first flew when a boat approached decreased from the pre-egg-laying period to hatching, and then increased slightly later in the season. Time ($\bar{x} \pm SE$) for skimmers to return to the nesting colony varied seasonally, with birds taking longer to return during the pre-egg period (9.5 ± 0.6 min) than during hatching (0.7 ± 0.1 min). The decision process for determining set-back distances to protect nesting skimmers should involve selecting 1) behavioral response of highest concern, 2) reproductive stage of highest concern, and 3) an appropriate level of response at which to establish the buffer area. We recommend that managers use a set-back distance of ≥ 118 m from the perimeter of the colony for black skimmers, which is the 95% percentile of the distance that skimmers first flew in response to approaching boats. Managers can use these data to set buffer distances for skimmers and other colonial birds.

Keywords: bird, United States, marine, wetland, motorized (boat)

Cardoni, D. A., M. Favero, and J. P. Isacch. 2008. Recreational activities affecting the habitat use by birds in Pampa's wetlands, Argentina: Implications for waterbird conservation. *Biological Conservation* **141**:797–806.

The increasing popularity of outdoor recreational activities in recent years has resulted in elevated human disturbance of waterbird communities. Anthropogenic disturbance is defined as any human activity that constitutes a stimulus sufficient to disrupt normal activities and/or distribution of animals relative to the situation in the absence of that activity. The goals of this study were (1) to quantify changes in habitat use by waterbirds caused by the proximity of people's activities to the shoreline, in Los Padres Lagoon Reserve (Argentina), (2) to evaluate differential responses of waterbird groups caused by this human disturbance, and (3) to propose management guidelines to improve waterbird conservation in Pampas lagoon. We performed bird surveys monthly in areas with high levels of disturbance (HD areas) and with no or low levels of disturbance (LD areas) via recreational activities during days with (weekends) and without (weekdays) presence of people close to the lagoon. We recorded 34 bird species using the lagoon. The bird richness and abundance in HD areas was higher in days without recreational activities, conversely, in LD areas we found no differences in these parameters between days. Waders were found to be the group most vulnerable to disturbance, since these birds were only recorded in HD areas in days without human activity. Podicipedidae, as a group were less affected by recreational activities. We detected changes in the waterbird assembles and structure in relation to the presence of people on the shoreline. Our results in this study suggest direct effects of recreational activities on the habitat use of waterbirds. The buffer area defined by the current Reserve management strategy is working properly, and the impact of recreational activities on transitional area has only instantaneous effects on waterbirds because they return to that area in absence of disturbance. However, it should be considered that we only estimated the response to short-term effects of these activities on the waterbird community. Further studies should assess long-term effects.

Keywords: bird, Argentina, shoreline, wetland, fishing (shore)

Cassini, M. H., D. Szteren, and E. Fernández-Juricic. 2004. Fence effects on the behavioural responses of South American fur seals to tourist approaches. *Journal of Ethology* **22**:127–133.

Animals that breed in coastal colonies, such as pinnipeds, usually attract tourism, which can negatively affect their resting and breeding behaviour if not managed properly. One strategy to reduce human disturbance is to set up fences, but little is known about their local effectiveness. Our purpose was to assess the behavioural

responses of South American fur seals (*Arctocephalus australis*) towards tourist approaches before and after the implementation of fences in Cabo Polonio colony (Uruguay). We found that human disturbance levels were similar between years and that the presence of a fence reduced (1) overall fur seal responses to tourists by 60%, (2) the most intense behavioural responses (threat, attack, leaving the colony) by more than half, (3) the responses to large tourist groups (>2 people), which were the most disturbing, (4) the responses to closer (<10 m) tourist approaches, and (5) the responses involving more intrusive tourist behaviours (running, shouting, hand waving). Overall, we showed that after the erection of the fence not only human–wildlife interactions were reduced but also the most stressful fur seal behavioural responses. Although further studies are necessary, our results suggest that the implementation of fences can be a simple and affordable means of minimising human disturbance effects on pinnipeds at local levels (e.g., within colonies), particularly if combined with other strategies (e.g., changes in tourist attitudes).

Keywords: mammal, Uruguay, shoreline, wildlife viewing (land)

Chwedorzewska, K., and M. Korczak. 2010. Human impact upon the environment in the vicinity of Arctowski Station, King George Island, Antarctica. *Polish Polar Research* **31**:45–60.

During thirty three expeditions to the Polish Arctowski Antarctic Station significant influences of human activity upon the environment have been recorded. Introductions of alien species, shifts of bird and seal breeding areas and decreases in both bird and seal populations, are the most obvious effects of human pressure. Though numbers of visits by tourists have increased during this period, impacts from expeditioners appear to be the main cause of changes. In particular, increasing numbers and mobility of summer groups at the station are the likely most influential factors.

Keywords: bird, mammal, Antarctica, polar

Claudet, J., P. Lenfant, and M. Schrimm. 2010. Snorkelers impact on fish communities and algae in a temperate marine protected area. *Biodiversity and Conservation* **19**:1649–1658.

Multiple-use marine protected areas (MPAs) are used to manage marine resources, allocate space to different users and reduce conflicts while protecting marine biodiversity. In the Mediterranean, MPA managers are increasingly interested in containing the effects of coastal recreation within underwater trails, but snorkelers impacts on the surrounding ecosystem remain largely unknown. In a Mediterranean MPA, an underwater snorkeling trail was established to concentrate snorkelers and increase their awareness of marine habitats and species. The high level of summer frequentation may have negative impacts on the surrounding environment through trampling on the sessile flora or disturbance to the vagile fauna. We used a before-after-control-impact (BACI) design to analyse these potential human impacts. The structure of macroalgae and fish assemblages were used as indicators. Permutational multivariate analyses of variance (PERMANOVA) were carried out to assess potential temporal and spatial changes of the indicators between the trail and a control location within the adjacent no-take/no-use area. Fish communities and macroalgae were subjected to natural temporal trends but no significant impacts of snorkelers were found. Four reasons could explain the absence of snorkelers impact on the surrounding marine environment: (1) the absence of very fragile organisms within the trail (and the control no-take/no-use area) such as gorgonians or bryozoans; (2) the life cycle of the algae with a natural decreasing trend in summer, corresponding to the trail opening period; (3) only a few snorkelers are practicing apnoea; and (4) the information at the entrance and along the trail may influence the snorkelers' behaviour.

Keywords: fish, France, marine, swimming/diving

Cobley, N. D., and J. R. Shears. 1999. Breeding performance of gentoo penguins (*Pygoscelis papua*) at a colony exposed to high levels of human disturbance. *Polar Biology* **21**:355–360.

Port Lockroy, situated on the Antarctic Peninsula, is one of the most visited tourist sites in Antarctica. The effects of visitor disturbance on the breeding performance of gentoo penguins (*Pygoscelis papua*) at Goudier Island, Port Lockroy was investigated during the austral summer of 1996/1997 by comparing pairs in treatment areas (visited by 35–55 tourists every 1–2 days) and control colonies (not visited by tourists). There were no differences between the two groups in the proportion of birds that laid, in hatching success or the proportion of single-chick broods. Pairs in treatment colonies laid a higher proportion of single-egg clutches, but this was related to colony location and unusually high snow accumulation. Most treatment colonies were situated on low-lying ground or in the lee of buildings, and probably had more late layers at the initial census. Only 11% of tourist visits had occurred by laying, making human disturbance an unlikely explanation for the higher proportion of single-egg clutches. Nests monitored in a disturbed colony and a control colony showed no differences in chick mass or survival up to 20 days of age. The overall breeding success, based on counts of creched birds, was similar to other southern populations of gentoo penguins, after correcting for mortality between creching and fledging. Historical data from Goudier Island indicate that the colony established itself in 1985 and has rapidly increased in size since then. The neighbouring colony at Alice Creek, which has been regularly visited by tourists for at least a decade, has also shown a population increase, although this expansion has been at a slower rate. We conclude that disturbance from tourist visits is unlikely to have been a major determinant of gentoo population change at Port Lockroy.

Keywords: bird, Antarctica, hiking, wildlife viewing

Colman, J. E., B. W. Jacobsen, and E. Reimers. 2001. Summer response distances of Svalbard reindeer *Rangifer tarandus platyrhynchus* to provocation by humans on foot. *Wildlife Biology* **7**:275–284.

The objective of our study was to examine response distances of Svalbard reindeer *Rangifer tarandus platyrhynchus* to direct provocation by humans on foot during summer in areas subject to combinations of high or low human activity, and hunting or no hunting. We hypothesised that Svalbard reindeer can become habituated to human activity even when hunted. Reindeer sight, fright, flight and running response distances were measured in response to direct provocation by humans on foot in five areas chosen for their degree of human activity and hunting. No differences in sight distance were found among the five areas. Reindeer in the area with the most human activity in summer and no hunting (Adventdalen) had shorter fright, flight and running distances than reindeer in the area with little human activity and no hunting (Reinsdyrflya). Reindeer response distances in the three areas with hunting and moderate human activity were similar and intermediate to areas with high and low human activity and no hunting. There were significant negative correlations between the fright, flight and running distances and the amount of human activity in an area, and with the exception of running distance having a borderline significant value, there were no correlations with intensity of hunting. Our findings suggest that Svalbard reindeer become habituated to human activity and that hunting probably has only a weak or even no influence on it. Furthermore, these findings do not lend support to the hypothesis that reindeer that are hunted by humans are less likely to habituate to human activity than those that are not hunted.

Keywords: mammal, Norway, tundra, hiking

Coma, R., E. Pola, M. Ribes, and M. Zabala. 2004. Long-term assessment of temperate octocoral mortality patterns, protected vs. unprotected areas. *Ecological Applications* **14**:1466–1478.

Coastal marine protected areas (MPAs) are usually established with an aim to protect areas of special ecological value. However, protected areas tend to attract more tourism and associated recreational activities, thereby exposing the biota to new risks such as high diving activity. The effects of these drawbacks are still little known for low-dynamic systems such as one of the most characteristic and fragile Mediterranean communities, the coralligenous community. Mortality rates were assessed in both heavily dived and lightly dived areas to evaluate the effect of diving on the survival of the gorgonian *Paramuricea clavata*. The study was designed to distinguish human-induced causes from natural causes of gorgonian mortality and to provide criteria for sustainable management of protected areas. We examined total and partial mortality of adult colonies (>10 cm in height) at four locations, two each representing one of the two situations, heavily dived (MPA) and lightly dived (control), annually over a 9-yr period (1992–2000). High levels of recreational activity did not affect the degree of injury of the colonies. On average, the proportion of live tissue of the colonies remained steady at 91%. Colony death by detachment was the main source of mortality at the MPA, four times higher than death due to overgrowth. Mortality rate due to overgrowth remained constant at both areas with an average of 1.2%/yr. Natural mortality rate in sites with low diving activity was estimated to be about 2.7%/yr, whereas high diving activity was estimated to increase the natural mortality rate of the species by a factor of three, up to 7.4%/yr. The demographic characteristics of long-lived low-turnover structural components of ecosystems makes them especially vulnerable to disturbance events. Since an increase in diving activity seems to be unavoidably brought about by the creation of any MPA, strict regulation of recreational activity must be guaranteed in areas with low-turnover communities.

Keywords: invertebrate, Spain, marine, swimming/diving

Comor, V., J. Orgeas, P. Ponel, C. Rolando, and Y. R. Delettre. 2008. Impact of anthropogenic disturbances on beetle communities of French Mediterranean coastal dunes. *Biodiversity and Conservation* **17**:1837–1852.

In coastal dunes, influenced by anthropogenic activities such as tourism, it is important to determine the relative influence of environmental factors at different spatial scales to evaluate the sensitivity of local communities to disturbances. We analyzed beetle communities of 14 dunes of the French Mediterranean coast: four in the relatively preserved Camargue area, and ten in the Var department, where tourism is intensive. Beetle communities were studied three times in early spring using sand sampling. Species-environment relationships were evaluated at the regional, landscape and local scale using redundancy analysis (RDA) and variability partitioning. About 28 species were identified, of which 15 were sand-specialist species, which accounted for more than 93% of total abundance. The beetle communities of Camargue were significantly different from those of the Var department owing to the pullulation of a Tenebrionid species (*Trachyscelis aphodioides* Latr.) in the Var, except for one restored dune where the community was very similar to those of Camargue. Our results showed no longitudinal gradient between the two regions. Local factors (dune height, preservation and disturbance index) significantly explained most of the variation in the dominance of *T. aphodioides*, while some other local factors were important for other psammophilous species. This study also suggests that dune beetle communities are strongly affected on beaches intensively managed for tourism, but beetles are still abundant in much disturbed sites.

Keywords: invertebrate, France, beach, shoreline, beach use

Constantine, R. 2001. Increased Avoidance of Swimmers by Wild Bottlenose Dolphins (*tursiops Truncatus*) Due to Long-Term Exposure to Swim-with-Dolphin Tourism. *Marine Mammal Science* 17:689–702.

The responses of wild, non-provisioned bottlenose dolphins (*Tursiops truncatus*) to swim attempts from commercial swim-with-dolphin tour boats were systematically observed during two research periods: 1994–1995 and 1997–1998. A total of 255 groups of dolphins was encountered during boat-based surveys and 36% (n= 93) were exposed to at least one swim attempt. The operators' success with swim attempts, defined as at least one dolphin milling within 5 m of at least one swimmer, decreased from 48% in 1994–1995 to 34% in 1997–1998, and avoidance responses to swimmers increased from 22% to 31%. Dolphin response was found to vary according to swimmer placement. The greatest increase in avoidance occurred when swimmers were placed in the dolphins' path of travel. Based on sighting records of 266 individually identified dolphins, it was estimated that an average dolphin was exposed to 31 swim attempts per year. This level of exposure suggests that individual dolphins have, with cumulative experience, become sensitized to swim attempts. When a swim attempt was successful, on average it involved 19% of the group. Age-class differences in interaction rates showed that juveniles were significantly more likely to interact with swimmers than adults. This study highlights the importance of longitudinal studies in evaluating human impact and suggests the urgent need for similar studies of potential human impact on other toothed cetaceans.

Keywords: mammal, New Zealand, marine, swimming/diving

Constantine, R., D. H. Brunton, and T. Dennis. 2004. Dolphin-watching tour boats change bottlenose dolphin (*Tursiops truncatus*) behaviour. *Biological Conservation* 117:299–307.

Over the last decade there has been considerable growth in marine mammal-watching tourism throughout the world. Due to the species use of coastal habitats, bottlenose dolphins are most frequently exposed to dolphin-watching tourism. We conducted boat-based focal follows of schools of bottlenose dolphins to determine the effect of boats on dolphin behaviour. A CATMOD analysis showed that behaviour differed by boat number, in particular, resting behaviour decreased as boat number increased. Dolphins rested less and engaged in more milling behaviour in the presence of permitted dolphin-watching boats compared to non-permitted boats. An increase from 49 to 70 permitted trips per week and a change in their departure times resulted in a further decrease in resting behaviour. Currently the effects of boats, in particular permitted boats, on dolphin resting behaviour whilst they are in the Bay of Islands, are substantial. In the light of these findings we suggest that current legislation in New Zealand is not affording this isolated population protection from disturbance.

Keywords: mammal, New Zealand, marine, wildlife viewing (boat)

Cooper, C. A., A. J. Neff, D. P. Poon, and G. R. Smith. 2008. Behavioral Responses of Eastern Gray Squirrels in Suburban Habitats Differing in Human Activity Levels. *Northeastern Naturalist* 15:619–625.

We observed the alert responses of *Sciurus carolinensis* (Eastern Gray Squirrel) to two different approach stimuli (human only and human with a leashed dog) in two suburban habitats differing in the level of human activity. Alert distance in the habitat with higher levels of human activity was significantly shorter than the alert distance in the habitat with lower levels of human activity. Overall, the alert distance did not differ

between the approach by a human alone and the approach by a human with a dog; however, in the high human activity sites (but not the low human activity sites), the presence of the dog increased alert distance in the squirrels. In addition, squirrels tended to initially respond by running more in the high human activity sites, but the presence of the dog increased the number of squirrels whose initial responses were to not run. Our results suggest that Eastern Gray Squirrel antipredator behavior, at least in response to humans and human-associated animals, is influenced by the level of human activity in the surrounding habitat.

Keywords: mammal, United States, forest, urban, hiking, dog-walking

Cornelius, C., S. A. Navarrete, and P. A. Marquet. 2001. Effects of Human Activity on the Structure of Coastal Marine Bird Assemblages in Central Chile. *Conservation Biology* **15**:1396–1404.

In comparison with the effects of the collection of marine intertidal organisms by humans, the effects of human recreational activities on assemblages of marine birds have received scarce attention. We evaluated whether in central Chile the spatial and temporal variation in the composition and abundance of the avian assemblage is affected by the presence of humans on the coast. We studied a 1.5-km stretch of rocky coast, in the center of which is a small marine reserve where no fishing or recreational activities take place. At 15 observation points, we conducted 12 monthly surveys of birds that roost in the supralittoral zone, between the high-tide mark and the terrestrial vegetation, and/or that forage in the intertidal zone. In addition, within the reserve we conducted daily bird surveys over 2 years to evaluate whether abundance or composition changed according to the activity of people outside the reserve. We recorded 19 species of coastal marine birds. Eleven species used the supralittoral zone only for roosting (roosting assemblage), whereas the others foraged on intertidal organisms and roosted in the supralittoral zone (foraging assemblage). Although the largest negative effect of human activity on bird abundance occurred in summer, the period of greatest recreation intensity, the presence of humans negatively affected birds year round, changing both the spatial and temporal distribution of birds along the shore. Bird abundance was higher at observation points inside the marine reserve, although the pattern was stronger for birds roosting on the supralittoral zone than for birds actively foraging in the intertidal zone. Similarly, the number of birds recorded during weekends inside the reserve was higher than during week days. Our results illustrate the important role played by this marine reserve, which offers marine birds safe roosting sites without human interference. Larger marine reserves than the one we studied are needed because the dynamics of birds inside the reserve were strongly influenced by human activities in immediately adjacent areas. Our results emphasize the need to consider human recreational activities along the coast when establishing conservation programs because harvesting refugia or "no-take" zones will not provide protection to coastal bird assemblages unless human access is restricted.

Keywords: bird, Chile, shoreline, fishing (shore)

Cunha, A. A. 2010. Negative effects of tourism in a Brazilian Atlantic forest National Park. *Journal for Nature Conservation* **18**:291–295.

Specific impacts and benefits of nature tourism on species, ecosystem and socio-economic aspects have to be addressed in detail. This study compared diurnal medium-large vertebrate richness and abundance in a visited (VT) and a non-visited trail (NVT) in the mountain forest of Serra dos Órgãos National Park (SONP), a priority area for nature conservation in the Atlantic Forest hotspot. Results suggest that richness and abundance of medium-large mammals and birds are significantly reduced in VT, however sample effort was insufficient for further analysis. In the absence of adequate data, protected area managers have to guarantee

infrastructure and control, but first, limit access by visitors, to small sized groups and low in frequency, guaranteeing large refuges for wildlife, and effective contributions for nature conservation with real socio-economic benefits at local and regional scales. The Brazilian government is investing in tourism in National Parks, including SONP, but there are no directives to monitor and manage potential negative impacts. Researchers and managers need to work together to couple this economic activity with environmental conservation in SONP and other protected areas in Brazil.

Keywords: mammal, Brazil, forest, hiking

Dans, S. L., M. Degradi, S. N. Pedraza, and E. A. Crespo. 2012. Effects of Tour Boats on Dolphin Activity Examined with Sensitivity Analysis of Markov Chains. *Conservation Biology* **26**:708–716.

Abstract: In Patagonia, Argentina, watching dolphins, especially dusky dolphins (*Lagenorhynchus obscurus*), is a new tourist activity. Feeding time decreases and time to return to feeding after feeding is abandoned and time it takes a group of dolphins to feed increase in the presence of boats. Such effects on feeding behavior may exert energetic costs on dolphins and thus reduce an individual's survival and reproductive capacity or maybe associated with shifts in distribution. We sought to predict which behavioral changes modify the activity pattern of dolphins the most. We modeled behavioral sequences of dusky dolphins with Markov chains. We calculated transition probabilities from one activity to another and arranged them in a stochastic matrix model. The proportion of time dolphins dedicated to a given activity (activity budget) and the time it took a dolphin to resume that activity after it had been abandoned (recurrence time) were calculated. We used a sensitivity analysis of Markov chains to calculate the sensitivity of the time budget and the activity-resumption time to changes in behavioral transition probabilities. Feeding-time budget was most sensitive to changes in the probability of dolphins switching from traveling to feeding behavior and of maintaining feeding behavior. Thus, an increase in these probabilities would be associated with the largest reduction in the time dedicated to feeding. A reduction in the probability of changing from traveling to feeding would also be associated with the largest increases in the time it takes dolphins to resume feeding. To approach dolphins when they are traveling would not affect behavior less because presence of the boat may keep dolphins from returning to feeding. Our results may help operators of dolphin-watching vessels minimize negative effects on dolphins.

Keywords: mammal, Argentina, marine, wildlife viewing (boat)

De la Torre, S., C. T. Snowdon, and M. Bejarano. 2000. Effects of human activities on wild pygmy marmosets in Ecuadorian Amazonia. *Biological Conservation* **94**:153–163.

The effects of tourism and human presence on the behavior and reproduction of pygmy marmosets *Cebuella pygmaea*, were evaluated in northeastern Ecuador. Field work was carried out from September 1996 to May 1998. Six groups of marmosets were observed in sites that differed in the number of tourists and use of motor boats. Reductions in social play and in the use of the lower stratum of the forests were significantly correlated with tourism pressure. Capture by local people of marmosets from two of the studied groups was associated with significant reductions in observability, vocalization rates and use of lower strata in these groups. All these behavioral changes may have allowed the marmosets to avoid contact with humans and were possibly related to differences in the reproductive performance of the groups. Recommendations are given for monitoring indicator species and for a better control of human activities in the area.

Keywords: mammal, Ecuador, forest, hiking, motorized (boat), wildlife viewing (land)

Devney, C. A., and B. C. Congdon. 2009. Testing the efficacy of a boundary fence at an important seabird breeding colony and key tourist destination. *Wildlife Research* **36**:353–360.

Tourists have the potential to detrimentally impact breeding seabirds, particularly at popular destinations such as on the Great Barrier Reef. Michaelmas Cay is a significant seabird rookery and prime tourist destination on the reef. In 1990, Queensland Parks & Wildlife Service erected a fence to separate tourists from fragile nesting habitat. We used two independent assessments during different breeding seasons to determine the potential impacts of tourism on two pelagic seabird species breeding on the cay. In the first quasi-experiment, egg losses by sooty terns (*Sterna fuscata*) and common noddies (*Anous stolidus*) were monitored at four distances (3, 6, 18 and 36 m) from a tourist enclosure. Our second quasi-experiment involved monitoring adult provisioning rates, chick growth and chick survival of sooty terns at two locations, one adjacent to the tourist fence and one 50 m away. At plots 3–6 m from the fence, we observed higher among-week variation in egg loss but no differences in total egg loss as compared with the more distant plots. The only difference observed between plots during our second quasi-experiment was that nest predation was higher at the tourist fence plot. Our research suggests that as long as the effects observed do not influence post-fledging survival or gull predation does not impact under different conditions, current management protocols are appropriately facilitating shared usage between wildlife and the tourism industry at Michaelmas Cay

Keywords: bird, Australia, shoreline, wildlife viewing (land)

Diego-Rasilla, F. J. 2003. Human influence on the tameness of wall lizard, *Podarcis muralis*. *Italian Journal of Zoology* **70**:225–228.

To investigate whether lizards may learn by experience to recognize, judge the intentions of, and decide when to escape from a potential predator, the wariness of wall lizards, *Podarcis muralis*, inhabiting a mountainous Spanish site frequented by tourists and another very close to it, scarcely accessible to people, was compared. Predation pressure on the area, estimated using soft plasticine replicas of lizards, seemed to be weak. Lizards at the tourist site were less wary, and had shorter approach distances (i.e., the distance lizards allowed the observer to approach before fleeing). Neither the total distance they fled in one continuous movement from their initial position until hiding or stopping at a safe distance (flight distance) nor the distance to the nearest refuge were significantly different between sites. Escape behaviour was not influenced by distance to cover at the tourist site, whereas, at the other, lizards were more wary, and fled from an approaching observer at greater distances when they were farther from a potential refuge

Keywords: reptile, Spain, grassland, hiking

Donaldson, R., H. Finn, L. Bejder, D. Lusseau, and M. Calver. 2012. The social side of human–wildlife interaction: wildlife can learn harmful behaviours from each other. *Animal Conservation* **15**:427–435.

Although harmful human–wildlife interactions involving anthropogenic food sources are a significant issue for wildlife conservation, few studies have addressed whether social learning may influence how animals learn to use anthropogenic foods. We examined a long-term (1993–2003) human–wildlife interaction involving the illegal feeding of bottlenose dolphins (*Tursiops aduncus*) by recreational fishers in south-western Australia.

We developed predictor variables for whether dolphins learned to accept food handouts from human provisioners, based on biological (age-class, sex) and behavioural (ranging and association patterns) data for a population of 74 dolphins. Two variables provided clear predictors for whether dolphins became conditioned to food handouts: the use of areas with high densities of recreational boats (BOAT) and the average coefficient of association with previously conditioned dolphins (ASSOC). An individual was more likely to become conditioned when it spent more time in high boat density areas and when it spent more time with other conditioned dolphins. When considering all the models available, there was strong weight of evidence for the effects of ASSOC and BOAT on the response variable. We were unable to detect any effects of age-class and sex with the available statistical power. These findings suggest that social learning can facilitate the acquisition of undesirable and maladaptive behaviours in wildlife, and indicate the value of long-term individual-specific data for the conservation management of wildlife engaging in undesirable interactions with humans.

Keywords: mammal, Australia, marine, wildlife feeding

Duchesne, M., S. D. Côté, and C. Barrette. 2000. Responses of woodland caribou to winter ecotourism in the Charlevoix Biosphere Reserve, Canada. *Biological Conservation* **96**:311–317.

We assessed the impact of ecotourist visits during winter on woodland caribou *Rangifer tarandus caribou* time budgets in the Charlevoix Biosphere Reserve, Canada. We compared the behaviour of caribou during and after ecotourist visits with their behaviour during days without visits. In the presence of ecotourists, caribou increased time spent vigilant and standing, mostly at the expense of time spent resting and foraging. After visits, caribou tended to rest more than during control days. Caribou reduced time spent foraging during ecotourist visits as the number of observers increased. The impact of ecotourists appeared to decrease as winter progressed. Visits were short ($\bar{x}=39.3$ min) and caribou never left their winter quarters because of human presence. However, caribou abandoned their wintering area twice in response to wolf presence. Although winter is a difficult period of the year for caribou, our results suggest that with proper precautions caribou in Charlevoix can tolerate ecotourist visits.

Keywords: mammal, Canada

Dyck, M. G., and R. K. Baydack. 2004. Vigilance behaviour of polar bears (*Ursus maritimus*) in the context of wildlife-viewing activities at Churchill, Manitoba, Canada. *Biological Conservation* **116**:343–350.

Viewing of polar bears (*Ursus maritimus*) from tundra vehicles has been offered at Churchill, Manitoba since the early 1980s. This form of wildlife viewing has provided a unique and safe way for tourists to learn about polar bears. However, these activities have largely been carried out without examining possible effects on polar bear behaviour. We studied vigilance behaviour (a scanning of the immediate vicinity and beyond) of resting polar bears to evaluate impacts from tundra vehicle activity. Focal animal sampling was used to examine whether a difference in vigilance behaviour existed when vehicles were present. We recorded the numbers of head-ups, vigilance bout length, and between-bout intervals for polar bears. In general, the frequency of head-ups increased, and the between-bout intervals decreased for male bears, when vehicles were present. Female bears behaved opposite to males. The vigilance bout lengths did not differ significantly between vehicle presence and absence. Vigilance behaviour of male bears was not magnified with increasing numbers of vehicles; therefore the threshold is one vehicle. We suggest that manipulative studies be conducted to examine

how distances between vehicles and bears, tundra vehicle activity in the immediate vicinity of a bear during viewing, and noise of tourists affect increased vigilance.

Keywords: mammal, Canada, shoreline, tundra, motorized (land), wildlife viewing (land)

El Alami, A., E. Van Lavieren, A. Rachida, and A. Chait. 2012. Differences in Activity Budgets and Diet Between Semiprovisioned and Wild-Feeding Groups of the Endangered Barbary Macaque (*Macaca sylvanus*) in the Central High Atlas Mountains, Morocco. *American Journal of Primatology* 74:210–216.

The Barbary macaque, *Macaca sylvanus* is a very adaptable primate species occupying a wide range of habitats in Morocco and Algeria. Several groups of this endangered macaque can be found in tourist sites, where they are affected by the presence of visitors providing food to them. We compare the activity budgets and the diet of semiprovisioned and wild-feeding groups of Barbary macaques in the central High Atlas Mountains of Morocco from February to August 2008. We used instantaneous scan sampling at 15-min intervals. The behaviors included in the activity budget were feeding, moving, foraging, resting, and aggressive display. Food items were grouped into seven categories. We found no differences between the two groups in the daily percentages of records attributed to feeding. The semiprovisioned group spent significantly more time engaged in resting and aggressive behavior, and foraged and moved significantly less than the wild-feeding group. There was no significant difference between the two groups in time spent eating leaves, fruits, or roots and bark. The semiprovisioned group, however, spent significantly less time per day feeding on herbs, seeds, and acorns than the wild-feeding group. Human food accounted for 26% of the daily feeding records for the semiprovisioned group and 1% for the wild-feeding group. Our findings agree with previous studies and indicate that in the tourist site, where food is highly clumped, macaques decreased foraging time yet showed higher levels of contest competition. Our results support the common claim that the diet of the Barbary macaque is highly flexible, differing among its varied habitats. Conservation efforts for the Barbary macaques should take into account the changes in behavior that human-modified environments may cause.

Keywords: mammal, Morocco, agricultural, forest, wildlife viewing (land)

Ellenberg, U., T. Mattern, and P. J. Seddon. 2009. Habituation potential of yellow-eyed penguins depends on sex, character and previous experience with humans. *Animal Behaviour* 77:289–296.

Animal populations are increasingly challenged by anthropogenic environmental changes. Species, populations and individuals vary in their ability to cope with exposure to human proximity. However, little is known about what drives habituation or sensitization in wild populations. Via behavioural observations and heart rate telemetry during experimental disturbance, we determined the habituation potential of yellow-eyed penguins, *Megadyptes antipodes*, a key species for nature-based tourism in southern New Zealand. Individual birds differed significantly in both their initial stress response and habituation potential. While some birds did not habituate, or even appeared to be sensitized by frequent disturbance, others habituated. Individual variation in habituation potential depended on previous experience with humans, sex and character (i.e. timid, calm or aggressive). Birds that were exposed to research that involved frequent interactions at the nest site, including blood sampling, several years prior to our experiments were less likely to habituate. Overall, females were more flexible than males in their stress response pattern, and calm individuals appeared to adapt more readily than aggressive birds. Character, classified during penguin–researcher interactions at the nest site, was independent of sex, age or previous experience, and was consistent over two seasons. Initial heart rate response to human approach, also similar between seasons, varied with sex and character of an individual.

Yellow-eyed penguins may habituate to short and consistent approaches, but appear unsuitable for unregulated tourist visits at nest sites. Individual differences in habituation potential to human disturbance can have fitness consequences and may lead to contemporary evolutionary change in the composition of breeding populations.

Keywords: bird, New Zealand, shoreline, hiking

Fairbanks, W. Sue, and Tullous, Randy. 2002. Distribution of pronghorn (*Antilocapra americana* Ord) on Antelope Island State Park, Utah, USA, before and after establishment of recreational trails. *Natural Areas Journal* **22**:277–282.

The distance of pronghorn (*Antilocapra americana* Ord) from recreational trails on Antelope Island State Park, Great Salt Lake, Utah, USA, recorded the year before the trails were opened for public use, was compared to distance from trails in three consecutive years after recreational use began. Groups of pronghorn were observed significantly farther from trails in years with recreational use than in the year before recreational use. There was no indication of habituation to recreational users over the three years. Analysis across years did not reveal particular sensitivity based on group composition, although distances of group types with the smallest mean group sizes (males only and females only) were significantly farther from trails in more years than groups with larger means (mixed sexes and groups with fawns). These results provide the first demonstration of a significant effect of nonconsumptive recreation on pronghorn. To minimize disturbance to wildlife, strategies to design and manage trails should be based on detailed studies of immediate behavioral responses to human recreational users.

Keywords: mammal, United States, grassland, scrub/shrub, biking, equestrian, hiking

Fernandez-Juricic, E., M. D. Jimenez, and E. Lucas. 2002. Factors affecting intra- and inter-specific variations in the difference between alert distances and flight distances for birds in forested habitats. *Canadian Journal of Zoology/Revue Canadienne de Zoologie* **80**:1212–1220.

Studies of escape from predators have usually focused on fleeing. We studied intra- and inter-specific variations in a previous level of decision-making during predator-prey encounters by determining the difference between the distance at which a predator is detected and the distance at which the prey flees from the predator (buffer distance). We measured buffer distances of four bird species (ground foragers) living in forested habitats (wooded recreational parks) to approaching humans. Buffer distances increased with group size and temperature, and this was probably related to dilution of the predation risk and a higher risk of heat stress, respectively. Buffer distances decreased with shrub and coniferous cover, probably because of increased visual obstruction, and increased with tree height, probably because of the increased security provided by taller trees. Grass cover increased buffer distances of wood pigeons (*Columba palumbus*) but decreased those of house sparrows (*Passer domesticus*) and magpies (*Pica pica*); this may be related to higher food availability, i.e., vegetation in grassy areas for wood pigeons and food left by humans in areas with bare ground for house sparrows and magpies. Buffer distances of blackbirds (*Turdus merula*) and house sparrows were greater in highly visited parks, which may be related to habituation. Finally, larger species showed greater buffer distances, landed farther away, used higher landing substrates (trees), and flew higher, probably because they need to ensure a certain margin of security from predators. Alternatively, the increased buffer distances of large species may be related to the increasing energy expenditure of flight. The buffer distance appears to be a good indicator of tolerance toward predators and (or) risk taken by prey after detecting predators.

Keywords: bird, Spain, forest, urban, hiking

Fernández-Juricic, E., M. P. Venier, D. Renison, and D. T. Blumstein. 2005. Sensitivity of wildlife to spatial patterns of recreationist behavior: A critical assessment of minimum approaching distances and buffer areas for grassland birds. *Biological Conservation* **125**:225–235.

A major goal of protected area management is to promote coexistence between wildlife and people and managers may restrict human activity by creating buffer zones. There are a number of assumptions implicit in establishing buffer zones that are typically based on how animals respond to approaching humans.

Conventional wisdom suggests that animals will be more sensitive to directly approaching humans than humans approaching tangentially. Visibility and detectability are important factors influencing a species' response to an approaching threat. Grasslands are an ideal system to study the different approach types because visibility is similar in all directions. We focused on five species of birds, four of them endemic, in the high Pampa de Achala mountain grassland of Argentina to study the effects of direct and tangential approaches on disturbance, and to evaluate five methods typically used to estimate buffer areas considering their sensitivity to the type of approach and their ability to estimate areas large enough to ensure the protection of the target species. We found that, contrary to conventional wisdom, four out of the five species showed greater flight initiation distance response to tangential rather than direct approaches, and that the minimum approach distance and buffer area estimates for these species varied significantly (in some cases an order of magnitude) between methods. Variability in the estimates between methods could be related to their different assumptions, which are not typically evaluated. More generally, we should be cautious when asserting that a buffer area calculated from direct approaches necessarily eliminates human disturbance.

Keywords: bird, Argentina, grassland, shrub/scrub, hiking

Fernández-Juricic, E., E. F. Zahn, T. Parker, T. Stankowich, and others. 2009. California's Endangered Belding's Savannah Sparrow (*Passerculus sandwichensis beldingi*): Tolerance of Pedestrian Disturbance. *Avian Conservation and Ecology-Écologie et conservation des oiseaux* **4**:1.

Salt marshes constitute habitat islands for many endemic animal species, particularly along the California coast, where urban sprawl has fragmented this habitat. Recreational activities in salt marshes have increased recently, posing an interesting problem: how do endemic species lacking alternative habitat modify their tolerance to humans? We assessed seasonal and site variations in three tolerance parameters (distances at which animals became alert, fled, and moved after fleeing) of California's endangered Belding's Savannah Sparrow (*Passerculus sandwichensis beldingi*). We approached individuals on trails in three salt marshes with different levels of vehicle and pedestrian traffic. Belding's Savannah Sparrows became aware and fled at shorter distances in the salt marsh coincident with greater levels of recreational activity as a result of habituation or visual obstruction effects. Seasonal effects in tolerance varied between sites. Alert and flight initiation distances were higher in the pre-nesting than in the non-breeding season in the site with the highest levels of recreational use likely due to greater exposure of breeding individuals; however, the opposite seasonal trend was found in each of the two sites with relatively lower human use, probably because individuals were less spatially attached in the non-breeding season when they foraged in aggregations. Distance fled was greater in the non-breeding than in the breeding season. Our findings call for dynamic management of recreational activities in different salt marshes depending on the degree of exposure to humans and seasonal variations in

tolerance. We recommend a minimum approaching distance of 63 m and buffer areas of 1.3 ha around Belding's Savannah Sparrows.

Keywords: bird, United States, marine, wetland, hiking

Fernández-Juricic, E., R. Vaca, N. Schroeder. 2004. Spatial and temporal responses of forest birds to human approaches in a protected area and implications for two management strategies. *Biological Conservation* 117:407-416.

Little is known about the responses of forest birds, other than raptors, to human disturbance despite their being highly sensitive to habitat disruption. We tested five hypotheses about the spatial and temporal interactions between recreationists and wildlife by using five South American birds as model species. We measured two components of flight distance, horizontal (distance between a visitor and the base of a perching tree) and vertical (distance between the base of a tree and the perch), and estimated the third diagonal component (distance between a visitor and the perch). We found that (a) the relationships between horizontal and vertical components of flight distance were negative (rufous-collared sparrow, golden-billed saltator, chiguanco thrush), positive (spot-winged pigeon), and neutral (bay-winged cowbird), suggesting that different components are used as clues to the proximity of people when birds vacated the perching tree; (b) the distance to the nearest pathway correlated positively with flight distance components of two species (bay-winged cowbird and spot-winged pigeon); and (c) physical structure of the vegetation affected differently flight distances of all species. Interspecific comparisons showed that (d) all flight distance components increased linearly with body size, and (e) species differed in landing distances but not in response duration: large-bodied species tended to land farther than smaller-bodied ones. By implementing buffer zones (areas without access to visitors), spatial restrictions would conflict with recreational activities. We recommend re-distributing (but not restricting) human visitation by varying the number of visitors and area of visitation according to the spatial requirements of differently sized species.

Keywords: bird, Argentina, forest, grassland, scrub/shrub, hiking

Ficetola, G. F., R. Sacchi, S. Scali, A. Gentilli, F. De Bernardi, and P. Galeotti. 2007. Vertebrates respond differently to human disturbance: implications for the use of a focal species approach. *Acta Oecologica* 31:109–118.

Focal species are surrogates assuming that all species under consideration respond similarly to the threatening processes. Focusing management only on a small number of species would improve conditions for other species. However, the across-taxa congruency of the response to threatening processes, and the subsequent efficiency of focal species as surrogates, has seldom been tested. In this study, we evaluated the effects of recreational disturbance and wood structure on the communities of terrestrial vertebrates in the wood patches of a large urban park. We measured two effects of recreation: direct disturbance (people presence) and litter disturbance (effect of trampling). We used multiple techniques to assess the distribution of small mammals, birds, reptiles and amphibians in 44 wood patches. Disturbance and wood maturity influenced the distribution of some species and the species richness of amphibians and reptiles; however, the pattern was not consistent across species within classes or among classes. The performance of focal species as a multi species umbrella was poor. Our results suggest that species specific differences in the response to the same source of disturbance can be strong; these differences can hinder the usefulness of focal species as surrogates and as a management tool.

Keywords: amphibian, bird, mammal, reptile, Italy, forest, grassland, urban

Finney, S., J. Pearce-Higgins, and D. Yalden. 2005. The effect of recreational disturbance on an upland breeding bird, the golden plover *Pluvialis apricaria*. *Biological Conservation* **121**:53–63.

The use of the countryside for recreation has increased dramatically in recent years. This has led to concern amongst conservationists about the effects increased human disturbance may have on important wild animal populations. In the UK, recent legislation has widened the level of access to upland habitats, which support internationally important breeding bird populations. Determining the extent to which recreational disturbance affects upland breeding birds is therefore a conservation priority. We used data collected over 13 years to investigate the impact of recreational disturbance on the distribution and reproductive performance of golden plovers breeding in close proximity to the Pennine Way, an intensively used long-distance footpath. Importantly, the Pennine Way was resurfaced in 1994 to prevent further erosion of the surrounding vegetation. We were therefore able to examine if the response of golden plovers to recreational disturbance was influenced by changes in the intensity and extent of human activity resulting from the resurfacing work. Before the Pennine Way was resurfaced, golden plovers avoided areas within 200 m of the footpath during the chick-rearing period. At this time over 30% of people strayed from the footpath and the movement of people across the moorland was therefore widespread and unpredictable. Following resurfacing, over 96% of walkers remained on the Pennine Way, which significantly reduced the impact of recreational disturbance on golden plover distribution; golden plovers only avoided areas within 50 m of the footpath at this time. Despite the clear behavioural responses of golden plovers to the presence of visitors, there was no detectable impact of disturbance on reproductive performance. In many countries, a conflict arises between the use of the countryside for recreational purposes and the protection of habitats or species of high conservation value. However, this study suggests that the implementation of simple measures to influence visitor behaviour can dramatically reduce the impact of recreational disturbance on wild animal populations.

Keywords: bird, United Kingdom, wetland, hiking

Fowler, G. S. 1999. Behavioral and hormonal responses of Magellanic penguins (*Spheniscus magellanicus*) to tourism and nest site visitation. *Biological Conservation* **90**:143–149.

One of the results of human disturbance at seabird colonies may be the provocation of the typical vertebrate adrenocortical response to stressors, but there have been few studies that demonstrate this. The present study demonstrates that simple human presence at the nest site, without effects of capture or handling, is physiologically stressful for breeding Magellanic penguins (*Spheniscus magellanicus*) that are not accustomed to seeing humans. It also demonstrates that birds that have been exposed to very high levels of human visitation via tourism do not respond to human presence as a stressor, whereas those exposed to moderate levels of disturbance do not show evidence of habituation over a period of a few years. These results suggest that tourist visits should be concentrated in a small part of breeding colonies, allowing birds nesting in the visitation area to habituate, leaving the remainder of the colony free of disturbance.

Keywords: bird, Argentina, hiking, wildlife viewing (land)

Galicia, E., and G. A. Baldassarre. 1997. Effects of Motorized Tourboats on the Behavior of Nonbreeding American Flamingos in Yucatan, Mexico. *Conservation Biology* **11**:1159–1165.

We assessed the effect of motorized tourboats on the behavior of nonbreeding American flamingos (*Phoenicopterus ruber ruber*) in the Celestún Estuary, a Special Biosphere Reserve in Yucatán, Mexico, from November 1994 through February 1995. We measured these effects by comparing activity budgets between flocks of flamingos disturbed and undisturbed by tourboats. Disturbance reduced feeding time from 40% before disturbance to 24% after, a 40% loss. Boat disturbance increased alert behavior by 400%. Tourboats averaged 13 per day and caused a disturbance 75% of the time or 3.3 hours per day. Potential loss of feeding time for individuals was estimated at 13% but is likely much higher on days with excessive numbers of tourboats. Flamingos returned to normal feeding rates (40%) within 20 minutes after disturbance. Most tourists (52%) were from Mexico, followed by Germany (14%), and 88% of Mexican visitors were willing to pay an entrance fee to the Celestún Reserve. Conservation efforts should focus on education of tourboat operators to reduce disturbance to flamingos, education of tourists through a visitor's center and brochures produced in Spanish and English, and expanded involvement of local people.

Keywords: bird, Mexico, freshwater, marine, wildlife viewing (boat)

Garber, S. D., and J. Burger. 1995. A 20-year study documenting the relationship between turtle decline and human recreation. *Ecological Applications* 5:1151–1162.

This study documents the detrimental effects of human recreation on the North American wood turtle (*Clemmys insculpta*) in Connecticut. We chronicled the dynamics of two allopatric wood turtle populations in a protected southern New England wildlife reserve for 20 yr (1974–1993). Both wood turtle populations were reproductively isolated from one another, physically separated ≈ 100 yr ago when a 1.5 km long human-made pond was constructed. We conducted a mark-and-recapture study on a 1000-ha section of a protected watershed in south-central Connecticut (New Haven County). During this study we monitored 133 different wood turtles, observing them a total of 1176 times. Human and wood turtle demographics were recorded throughout this period. The data support the following conclusions: (1) following a period of apparent stability, two populations of wood turtles declined; (2) the declines were more or less synchronous in both populations; (3) the beginning of each decline corresponded to the opening of the habitat for recreation; (4) an increase in mean turtle age suggests a failure of recruitment; however, (5) a simultaneous reduction in numbers of adult females suggests that the failure of recruitment alone is not sufficient to explain the declines. Throughout our study the size of the forest remained the same, road building was restricted, and the quality of the air and water were constant. The wood turtle populations remained stable when people were denied access to the property. When this area was opened to human recreation (hiking, fishing) the two discrete wood turtle populations declined steadily; the total number of turtles in both populations declined by 100% in 10 yr. As wilderness areas become mixed-use recreation areas, wood turtle populations may suffer. We conclude that without proper management, the increasing recreational use of parks, reservoirs, and wildlife reserves will adversely affect the long-term survival of the North American wood turtle.

Keywords: reptile, United States, freshwater, forest, hiking, fishing

George, S. L., and K. R. Crooks. 2006. Recreation and large mammal activity in an urban nature reserve. *Biological Conservation* 133:107–117.

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.

Keywords: mammal, United States, grassland, shrub/scrub, urban, hiking, biking, motorized (land), equestrian, dog-walking

Gerrodette, T., and W. G. Gilmartin. 1990. Demographic Consequences of Changed Pupping and Hauling Sites of the Hawaiian Monk Seal. *Conservation Biology* 4:423–430.

During the last 30 years, changes in the size of Hawaiian monk seal populations at several locations have been associated with the amount and type of human disturbance. Recreational beach activities caused monk seals to alter their pupping and hauling patterns. Survival of pups in suboptimal habitats was low, leading to gradual population declines. During the last decade at Kure Atoll, the process has been reversed: human disturbance on beaches has decreased, and traditional pupping and hauling sites have been reestablished. Subsequently, high survival rates of young seals, coupled with two successful enhancement programs for female pups, have led to dramatic changes in the age and sex composition of the population. Based on these changes, the monk seal population at Kure Atoll soon should begin to increase. Apparently small behavioral changes in such vital activities as feeding and reproduction can have large demographic consequences. Therefore, monitoring of endangered species should include data on habitat use and age and sex composition, as well as estimates of abundance.

Keywords: mammal, beach

Giese, M. 1996. Effects of human activity on adelic penguin *Pygoscelis adeliae* breeding success. *Biological Conservation* 75:157–164.

Adelic penguin *Pygoscelis adeliae* colonies were exposed to two forms of human activity currently occurring in Antarctica: nest checking for scientific purposes and recreational visits (disturbance treatments). Hatching success and chick survival at these colonies were compared to that at an undisturbed (control) colony. Six colonies were used — three larger (mean of 70 nests) and three smaller (mean of 44 nests). Treatments (nest checking, recreational visits and control) were each replicated at one colony of each size. For both larger and smaller colonies, hatching success and chick survival were highest at control colonies and lowest at colonies subjected to recreational visits. These differences were statistically significant between smaller colonies where

hatching success was 35% lower in the colony subjected to nest checking (compared to the control colony) and 47% lower in the colony subjected to recreational visits. For chick survival these reductions were 72% and 80% respectively. No significant difference was found in breeding success (hatching success or chick survival) between the two disturbance treatments (nest checking and recreational visits) in either size class. Disturbance treatment and colony size both influenced hatching success and chick survival significantly, but there was no statistical interaction between these parameters. Penguins bred either in the centre of a colony or at its periphery had no significant influence upon their breeding success.

Keywords: bird, Antarctica, polar, wildlife viewing (land)

Gill, J. A., K. Norris, and W. J. Sutherland. 2001. The Effects of Disturbance on Habitat Use by Black-Tailed Godwits *Limosa limosa*. *Journal of Applied Ecology* **38**:846–856.

1. Human disturbance of wildlife is widely considered to be a serious conservation problem. However, despite many qualitative studies, little attempt has been made to assess whether human presence limits the number of animals that sites can support. This can be quantified by incorporating measures both of human presence and of resource distribution into analyses of population distribution. The effects of disturbance can then be measured from any reduction in resource use at disturbed sites, which in turn indicates any reduction in the number of animals supported. 2. Shorebirds are often considered highly susceptible to disturbance because of their very obvious flight responses to humans and because they use areas that are generally subject to high levels of human recreational use. 3. This study addressed the effect of human presence on the distribution of black-tailed godwits *Limosa limosa islandica* on coastal areas in eastern England. We identified the prey types selected by godwits and related their depletion to different levels and types of human disturbance at a range of spatial scales. 4. Three methods of analysis are described: simple regressions of the effect of human activity on the number of godwits supported; multiple regression analyses of the effect of human presence and prey density on godwit numbers; and analyses of the effect of human presence on prey density at the end of the season. The latter method assumes that godwits are responsible for the majority of resource depletion. None of the analyses showed any effect of human presence on the number of godwits supported by the food supply at any of the spatial scales examined. 5. Many species may appear to avoid human presence but this may not reduce the number of animals supported in an area. Assessing the influence of disturbance on the relationship between animal distribution and resource distribution provides a means of assessing whether numbers are constrained by disturbance.

Keywords: bird, invertebrate, United Kingdom, freshwater, marine, shoreline, boating, hiking, motorized (boat)

Glover, H. K., M. A. Weston, G. S. Maguire, K. K. Miller, and B. A. Christie. 2011. Towards ecologically meaningful and socially acceptable buffers: Response distances of shorebirds in Victoria, Australia, to human disturbance. *Landscape and Urban Planning* **103**:326–334.

Buffers are often used to separate threatening stimuli, such as humans, from wildlife but with few exceptions buffer widths are based on little empirical information. We measured the distance at which a response (i.e., flight initiation distance [FID]) occurred among 28 of Australia's 36 regularly occurring shorebird species when presented with an approaching human ($n = 760$ approaches in Victoria, south eastern Australia). Species differed in their FID, with species with higher body masses having longer FIDs ($F_{1,26} = 36.830$, $p < 0.001$; $R^2 = 0.586$). Mean FIDs for species were 18.6–126.1 m ($n = 370$ approaches by a walker).

Depending on the species, FID was significantly influenced by the starting distance of the human approach, flock size, previous exposure to humans and stimulus type (walker, jogger, walker with dog). The FIDs reported suggest that current buffer designations will reduce disturbance to many but not all shorebird species tested. We also surveyed 295 residents and users of shorebird habitat, who reported an overall positive attitude to shorebird conservation, and generally regarded buffers as an appropriate way of managing disturbance to shorebirds (except for walkers, the commonest recreational activity). By overlaying the buffer widths nominated by respondents as appropriate for shorebirds with the FIDs exhibited by shorebirds, we present the efficacy of buffers from both social and ecological perspectives.

Keywords: bird, Australia, beach, freshwater, shoreline, dog-walking, hiking, jogging/running

Goldstein, M. I., A. J. Poe, L. H. Suring, R. M. Nielson, and T. L. McDonald. 2009. Brown Bear Den Habitat and Winter Recreation in South-Central Alaska. *Journal of Wildlife Management* 74:35–42.

Increasing demand for backcountry recreation opportunities during winter (e.g., snowshoeing, helicopter-assisted skiing, snowmobiling) in steep, high-elevation terrain has elevated concern about disturbance to brown bears (*Ursus arctos*) denning on the Kenai Peninsula, Alaska, USA. To help identify areas where such conflicts might occur, we developed a spatially explicit model to predict potential den habitat. The model indicated brown bears selected locations for den sites with steep slopes, away from roads and trails. Den sites were associated with habitat high in elevation and away from potential human contact. We then compared areas with the highest probability of providing den habitat with patterns of snowmobile and nonmotorized recreation on a portion of the Kenai Peninsula. We found limited overlap between the 2 recreation activities and potential den habitat for brown bears. At the landscape scale, however, backcountry skiing overlapped more high-quality den habitat than did snowmobile riding. Our results may be used by land management agencies to identify potential conflict sites and to minimize the potential effects of recreation activities on brown bears in dens.

Keywords: mammal, United States, forest, tundra, motorized (land)

Griffin, S. C., T. Valois, M. L. Taper, and L. Scott Mills. 2007. Effects of tourists on behavior and demography of olympic marmots. *Conservation Biology* 21:1070–1081.

Abstract: If changes in animal behavior resulting from direct human disturbance negatively affect the persistence of a given species or population, then these behavioral changes must necessarily lead to reduced demographic performance. We tested for the effects of human disturbance on Olympic marmots (*Marmota olympus*), a large ground-dwelling squirrel that has disappeared from several areas where recreation levels are high. We assessed the degree to which antipredator and foraging behavior and demographic rates (survival and reproduction) differed between sites with high recreation levels (high use) and those with little or no recreation (low use). Compared with the marmots at low-use sites, marmots at high-use sites displayed significantly reduced responses to human approach, which could be construed as successful accommodation of disturbance or as a decrease in predator awareness. The marmots at high-use sites also looked up more often while foraging, which suggests an increased wariness. Marmots at both types of sites had comparable reproductive and survival rates and were in similar body condition. Until now, the supposition that marmots can adjust their behavior to avoid negative demographic consequences when confronted with heavy tourism has been based on potentially ambiguous behavioral data. Our results support this hypothesis in the case of

Olympic marmots and demonstrate the importance of considering demographic data when evaluating the impacts of recreation on animal populations.

Keywords: mammal, United States, grassland, hiking

Grubb, T. G., D. K. Delaney, W. W. Bowerman, and M. R. Wierda. 2010. Golden Eagle Indifference to Heli-Skiing and Military Helicopters in Northern Utah. *Journal of Wildlife Management* **74**:1275–1285.

In 2006–2007, during Wasatch Powderbird Guides (WPG) permit renewal for heli-skiing in the Tri-Canyon Area (TCA) of the Wasatch Mountains, Utah, USA, we recorded 303 helicopter passes between 0 m and 3,000 m (horizontal distance) near ≥ 30 individual golden eagles (*Aquila chrysaetos*) in 22 nesting territories, through passive observation and active experimentation with civilian and military (Apache AH-64) helicopters. Flight profiles included 800-m, 400-m, 200-m, and 100-m flybys (horizontal distance from cliff nest on parallel course), as well as approaches and popouts where helicopters flew toward, or popped out from behind, adult-occupied cliff nests (0 m, horizontal distance). Between 1981 and 2007, during the only 8 years when nesting in the TCA was confirmed by presence of chicks, WPG annually flew 108–2,836 helicopter flights in the same drainages on 10–37 days between 15 December and 15 April, with no effect on early courtship, nest repair, or subsequent nesting success. Total WPG operating days ($\bar{x} = 62.4$) and helicopter hours ($\bar{x} = 210.6$) fluctuated annually but did not increase 1974–2007 (Cox-Stuart trend test, $P = 0.371$, 0.393 , respectively). Apache helicopter testing (227 passes) did not reduce golden eagle nesting success or productivity rates within the same year ($t_{111,96} = 0.495$, 0.782 , $P = 0.622$, 0.436 , respectively), or rates of renewed nesting activity the following year, compared with 81–101 non-manipulated nesting territories. We recorded no response during 66% and only watching during 30% of Apache passes at 0–800 m from nesting golden eagles. No other reactions occurred until after hatching when ≤ 4 golden eagles accounted for 5 flatten and 3 fly behaviors at 3 nest sites. No responding pairs failed to fledge young because of testing. Limited fly responses suggested helicopters only precipitated an imminent departure, rather than causing startled, avoidance reactions. Responsiveness between test weeks 1 and 2 decreased ($X^2_2 = 32.167$, $P \leq 0.001$). Apache helicopters were twice as loud as WPG helicopters at comparable distances. Sound decreased with distance, most rapidly when flights were perpendicular to cliffs or ridges. Eagle ambient behaviors and watching the helicopter occurred randomly throughout recorded sound levels during helicopter testing (76.7–108.8 decibels, unweighted). Much helicopter sound energy is below golden eagles' auditory threshold, thus reducing potential impacts. Neither our observations nor our testing indicated special management restrictions are required for helicopters flying near nesting golden eagles in northern Utah. Our results underscore the necessity for circumstance-specific research, as well as enlightened resource management to accommodate unexpected results.

Keywords: bird, United States, forest, alpine ski/snowboard

Guillemain, M., R. Blanc, C. Lucas, and M. Lepley. 2007. Ecotourism disturbance to wildfowl in protected areas: historical, empirical and experimental approaches in the Camargue, Southern France. *Biodiversity and Conservation* **16**:3633–3651.

Ecotourism is becoming very popular, especially in protected areas where wildlife concentrate and is easier to observe, but the consequences of associated disturbance have seldom be quantified other than in the short-term, making the sustainability of this activity untested. We combined a historical, an empirical and an experimental approach to assess the long-, medium- and short-term consequences of disturbance to wintering

wildfowl (Anatidae) in a wetland of international importance in the Camargue, Southern France. In the short-term, disturbance made teal (*Anas crecca*) move away temporarily from observation blinds without leaving the waterbody. Wildfowl fed more after disturbance, disrupting their normal resting activities. In the medium-term, waterbodies with more tourists did not host fewer birds: conversely the most heavily disturbed one hosted the highest wildfowl density. In the long term, wildfowl numbers were not related with the number of visitors. When practiced with appropriate guiding of people, and where appropriate facilities are provided to limit human disturbance as done here, ecotourism may not affect wintering wildfowl other than reversibly in the very short term. The legitimate demand of the public for access, even in fragile protected areas, may therefore be sustainable under some conditions.

Keywords: bird, France, wetland, wildlife viewing (land)

Gutzwiller, K. J., S. K. Riffell, and S. H. Anderson. 2002. Repeated Human Intrusion and the Potential for Nest Predation by Gray Jays. *The Journal of Wildlife Management* **66**:372–380.

Through attraction of avian nest predators, human activity near nests is known to cause lower nesting success or nest failure in some species. This is a significant conservation issue because many wildlands are subjected to repeated intrusion by recreationists, ecotourists, and other user groups during avian breeding seasons. Yet, wildlife scientists still have limited knowledge about the extent to which repeated human intrusion attracts avian nest predators. We studied this topic in subalpine forest in Wyoming, USA, and experimented with the gray jay (*Perisoreus canadensis*), a nest predator that is known to approach recreationists. During 1989-1993, we implemented intrusions within 20 circular 1-ha (113-m-diam) sites for 1 or 2 hr each week during a 10-week period when potential passerine prey were breeding. Simultaneously, 10 circular 1-ha control sites did not receive experimental intrusions. The average number of gray jays on intruded sites was higher than that on control sites by 156% (1989), 225% (1990), 59% (1991), 13% (1992), and 29% (1993). The probability of gray jay recurrence on intruded sites was higher than that on control sites by 125% (1989), 300% (1990), 20% (1991), 33% (1992), and 20% (1993). By increasing the number and recurrence of gray jays, relatively low levels of repeated intrusion can increase the potential for nest predation by gray jays. We caution that additional work is necessary to assess whether attraction of gray jays actually leads to increased nest predation. Knowledge of when intrusion does and does not attract gray jays is important because information about both events is necessary to define the levels and circumstances of intrusion that are influential. Wildlife managers can use knowledge about intrusion-induced attraction of avian nest predators to help decide whether or how recreational activity in wildlands should be managed.

Keywords: mammal, United States, forest, hiking

Hawkins, J. P., and C. M. Roberts. 1992. Effects of recreational SCUBA diving on fore-reef slope communities of coral reefs. *Biological Conservation* **62**:171–178.

This study investigated the effects of recreational SCUBA diving on the fore-reef slopes of coral reefs near Sharm-el-Sheikh, a popular resort in Egypt. Benthic communities were compared using randomly placed 1-m² quadrats at three sites subdivided into heavily and little dived areas. There were significantly more damaged coral colonies, loose fragments of live coral, fragments of coral re-attached to the substratum, partially dead and abraded corals in areas heavily used by divers than in control areas. Damage to corals varied with growth form, branching forms being most vulnerable to breakage. Changes to communities at heavily and little dived sites were studied over 12 months using 3 × 3 m permanent quadrats. No significant increases

in damage attributable to diving were detected for the three sites combined. However, when considered individually, the site which had experienced the greatest increase in diving appeared to have accumulated damage (broken coral) whereas the two others did not. For management purposes the results show that some reefs can sustain heavy levels of diving without apparent continued degradation. New dive sites can accumulate damage very rapidly. However, at the levels of diver use encountered during this study this may be more of an aesthetic than a biological problem.

Keywords: invertebrate, Egypt, marine, swimming/diving

Hawkins, J. P., and C. M. Roberts. 1993. Effects of Recreational Scuba Diving on Coral Reefs: Trampling on Reef-Flat Communities. *Journal of Applied Ecology* **30**:25–30.

1. This study investigated the effects of trampling by scuba divers and snorkellers on reef-flats of coral reefs near Sharm-el-Sheikh, a popular resort in Egypt. 2. There were significantly more damaged coral colonies and loose fragments of live coral in heavily-trampled than in little-trampled areas. Percentage cover of bare rock and rubble was also significantly greater; conversely, numbers of hard coral colonies and total percentage live coral cover were lower. 3. Coral colonies were smaller in trampled compared to control areas, with average height and diameter significantly less in heavily-trampled areas. An area regularly visited by snorkellers exhibited intermediate effects. 4. Coral species composition and the relative abundances of different coral growth forms did not appear to be affected by trampling. 5. Several of the effects detected differed between outer and middle zones of the reef-flat, suggesting that some communities were more vulnerable to trampling than others. 6. In addition to causing biological damage, trampling reduced the aesthetic appeal of the reef-flat for tourists. An effective management strategy might therefore be to contain trampling within narrow areas rather than allowing free access by divers.

Keywords: invertebrate, Egypt, marine, swimming/diving

Hawkins, J. P., C. M. Roberts, T. V. Hof, K. D. Meyer, J. Tratalos, and C. Aldam. 1999. Effects of Recreational Scuba Diving on Caribbean Coral and Fish Communities. *Conservation Biology* **13**:888–897.

Scuba diving on coral reefs is an increasingly lucrative element of tourism in the tropics, but divers can damage the reefs on which tourism depends. By studying the effects of diving we can determine what level of use is justifiable in balancing objectives of economic gain and conservation. Off the Caribbean island of Bonaire we compared coral and fish communities between undived reserves and environmentally similar dive sites where maximum use reached 6000 dives per site per year. At these levels of diving, direct physical damage to reefs was relatively minor. There were more loose fragments of living coral in dive sites than reserves and more abraded coral in high- than low-use areas. Diving had no significant effect on reef fish communities. Between 1991 and 1994, diving intensity increased 70% and coral cover declined in two of three dive sites and in all three reserves, suggesting a background stress unrelated to tourism. There was a significant decline in the proportion of old colonies of massive coral species within dive sites (19.2% loss), compared to a smaller loss in reserves (6.7%). Branching corals increased by 8.2% in dive sites, compared with 2.2% in reserves. Despite close management of reefs, diving is changing the character of Bonaire's reefs by allowing branching corals to increase at the expense of large, massive colonies. The impact of background stresses on massive corals seems to have been greater in the presence of diving. Other studies have linked disease infection to coral tissue damage, and the higher rates of abrasion we recorded in dived sites could have rendered corals there more susceptible to disease, thus mediating the decline of massive corals. Our study

shows that even relatively low levels of diving can have pronounced effects manifested in shifts in dominance patterns rather than loss of overall coral cover. Bonaire's reefs have among the highest coral cover and greatest representation of ancient coral colonies of reefs anywhere in the Caribbean. Conserving the character of these reefs may require tighter controls on diving intensity.

Keywords: fish, invertebrate, Netherlands Antilles, marine, swimming/diving

Hayward, M., and G. Hayward. 2009. The impact of tourists on lion (*Panthera leo*) behaviour, stress and energetics. *Acta Theriologica* **54**:219–224.

African conservation areas are internationally sought out as destinations to observe charismatic megafauna. Recently, research has identified that wildlife can become stressed at the presence of human observers and tourists. We investigated the impact of tourist presence and absence on the reintroduced lion *Panthera leo* Linnaeus, 1758 population in Addo Elephant National Park, South Africa, by measuring the frequency of disturbance-indicating (yawning, sitting, standing, moving away) and relaxation-indicating (rolling, grooming) behaviours when tourists were present and absent. Lions were significantly more likely to exhibit disturbance behaviours when tourists were present, and significantly more likely to perform relaxation behaviours when tourists were absent. We also measured the number of breaths per minute, as an indicator of stress, and found that this also increased in the presence of tourists. Lions incur stress and an energetic cost (albeit minor) from being observed by tourists. Some lion populations may face this chronically, which may increase their susceptibility to disease by reducing their immunity. Enforcing rules banning off-road driving in pursuit of wildlife and ensuring adequate refuge away from tourist infrastructure are important methods to minimise the stressful impacts of tourists on wildlife.

Keywords: mammal, South Africa, wildlife viewing (land)

Heil, L., E., Fernandez-Juricic, D. Renison, A. M. Cingolani, and D. T. Blumstein. 2007. Avian responses to tourism in the biogeographically isolated high Cordoba Mountains, Argentina. *Biodiversity and Conservation* **16**:1009–1026.

Species do not respond identically to the presence of humans, and this may have consequences at higher-levels of ecological organization. We established bird transects on and off recreational trails in the high Cordoba Mountains of Argentina, a biogeographic island characterized by high levels of endemism, to examine the effect of human visitation at three different levels: (a) community (avian species richness and diversity), (b) guild (relative density of carnivores, granivores, insectivores, and omnivores), and (c) population (relative density of individual bird species). Human presence in the high Cordoba Mountains decreased avian species richness and diversity, and reduced insectivorous relative density, but we did not detect significant effects on granivores, omnivores, and carnivores. At the population level, 6 of 28 species were negatively affected by human visitation; four of these species are of conservation concern. Our results show negative responses to recreationists at multiple levels (e.g., reductions in density, displacement of species from highly visited areas), which may be related to spatial and temporal access to suitable resources, physical disturbance or species-specific tolerance thresholds. Our study area had lower levels of human visitation relative to other protected areas in the Northern Hemisphere, which raises the issue of whether this kind of biogeographically isolated habitat may be too fragile to sustain increasing levels of tourism.

Keywords: bird, Argentina, grassland, scrub/shrub, biking, equestrian, hiking

Heyman, W., L. Carr, and P. Lobel. 2010. Diver ecotourism and disturbance to reef fish spawning aggregations: It is better to be disturbed than to be dead. *Marine Ecology Progress Series* **419**:201–210.

Dive tourism, with proper diver training, is often suggested as an environmentally benign and economically viable alternative to commercial fishing of coral reef fishes, affording, for example, unique opportunities to see large schools of spawning fish or encounter whale sharks *Rhincodon typus*. Yet, the ancillary effects of groups of divers disrupting fish spawning aggregations (FSAs) must be assessed. We examined over 9 h of video footage (extracted from over 100 h of underwater video) filmed at FSA sites in Belize. The footage captured divers interacting with schools of snappers and groupers as they aggregated to spawn, as well as showing the arrival of whale sharks. Diver behaviors included both video recording and flash still photography of fish schools and tagging of whale sharks. We filmed 746 unique diver–school interactions that included total observations of approximately 200000 snappers, 4700 Nassau groupers *Epinephelus striatus* and 200 whale sharks. We recorded 180 spawning events, only 105 of which showed divers disturbing aggregating schools, which affected an estimated 2100 snappers and 90 groupers. We conclude that small groups of experienced divers, following a code of responsible diving centered upon the precautionary principle and sensitivity to fish schooling behaviors, do not negatively affect schooling or spawning behaviors. Though further research is needed to assess the effects of boat traffic and larger groups of less experienced divers, dive ecotourism at fish spawning areas represents an economically attractive and less exploitative alternative to commercial fishing.

Keywords: fish, Belize, marine, swimming/diving

Hines, K. N. 2011. Effects of Ecotourism on Endangered Northern Bahamian Rock Iguanas (*Cyclura* *Cyclura*). *Herpetological Conservation and Biology* **6**:250–259.

This study evaluated effects of tourist visitation and supplemental feeding on the Northern Bahamian Rock Iguanas (*Cyclura cyclura*) in the Exumas, The Bahamas. The study examined flight behavior and diet on islands that were visited versus those not visited by tourists. Iguanas on visited islands were less wary of human presence than those on non-visited islands. Unlike on non-visited islands, iguanas on beaches where they were fed by tourists consumed people-influenced items including trash (e.g., styrofoam, aluminum foil), non-native fruits and vegetables (e.g., grapes, tomatoes), and sand. Non-native fruits provided a higher liquid content diet than did native vegetation, which, when mixed with sand, created cement-like feces that may have medical consequences. Tourism has encouraged an increase in these iguana populations, but it is now clear that negative impacts, such as loss of wariness and dietary shifts shown in this study as well as possible demographic consequences, also are occurring. These adverse effects might be ameliorated by changed practices, but such changes must be instituted with full participation by local stake holders.

Keywords: reptile, Bahamas, shoreline, wildlife feeding, wildlife viewing (land)

Hodgson, A. J., H. Marsh, and P. J. Corkeron. 2004. Provisioning by tourists affects the behaviour but not the body condition of Mareeba rock-wallabies (*Petrogale mareeba*). *Wildlife Research* **31**:451–456.

Feeding free-ranging native animals is a form of wildlife-based tourism that is particularly popular in Australia as a result of the cryptic nature of many native species. The colony of Mareeba rock-wallabies (*Petrogale mareeba*) at 'Granite Gorge', North Queensland, where tourists feed a spatially defined subset of animals

daily, was studied to determine the effects of provisioning on their behaviour and body condition. Provisioned *P. mareebah* had higher activity levels, including higher aggression levels, and spent more time performing contact behaviours (including mutual and non-mutual allogrooming) than did non-provisioned animals. Possible explanations for increased aggression include competition over provisioned food and territorial defence. Increased contact behaviours may serve to reduce tension caused by provisioning. The diurnal activities of the provisioned rock-wallabies were dictated by the activities of tourists. Provisioned rock-wallabies emerged from their shelters to receive food much earlier each afternoon than did the unprovisioned animals. The level of autogrooming exhibited by the provisioned wallabies was much higher than that of the unprovisioned animals, presumably as a thermoregulatory response to the high afternoon temperatures. Although provisioned *P. mareeba* feed more, their higher activity levels explain the lack of difference in the body condition between the two groups.

Keywords: mammal, Australia, forest, grassland, wildlife feeding

Holcomb, K., J. K. Young, and L. R. Gerber. 2009. The influence of human disturbance on California sea lions during the breeding season. *Animal Conservation* **12**:592–598.

California sea lions *Zalophus californianus* occupy 26 islands in the Gulf of California (GoC), Mexico. Although human presence is prohibited on these islands without a government permit, the law is not enforced and tourism to the islands is increasing. Tourists, along with local fishermen, often come ashore to get close to the animals, which may disrupt behaviors critical for reproduction. In this paper, we report the results of an experimental study on the behavioral effects of human disturbance on California sea lions in the GoC. To document effects, we recorded sea lion behavior immediately before and in 10-min intervals for up to an hour after experimental human disturbance. Our results showed few behavioral responses of sea lions to human disturbance. Adult females and juveniles demonstrated immediate responses, but these were not consistent between years, apparent an hour after disturbance, or evident across other age and sex classes. These results suggest that California sea lions may be resilient to human disturbance and a possible flagship species for ecotourism, but further studies of the physiological and population-level effects of human disturbance are needed.

Keywords: mammal, Mexico, shoreline, hiking

Holmes, N. D. 2007. Comparing King, Gentoo, and Royal Penguin Responses to Pedestrian Visitation. *Journal of Wildlife Management* **71**:2575–2582.

For wildlife managers, determining inter-species differences in the behavioral responses of seabirds to visitation can allow greater efficacy of visitor guidelines. Two key management outcomes for such information include 1) tailoring visitor guidelines to protect the most sensitive species and 2) improving self-regulation during visits by identifying behaviors likely to indicate a change in the natural activity of visited species. On subantarctic Macquarie Island, Australia, I collected the behavioral responses of guarding king (*Aptenodytes patagonicus*), gentoo (*Pygoscelis papua*), and royal (*Eudyptes schlegeli*) penguins before, during, and after exposure to a standardized pedestrian visit, to compare species' behavioral responses to visitation. Gentoo penguins appeared more sensitive than royal or king penguins, exhibiting altered behavior for 5 minutes after the stimulus was removed; this pattern was not evident in kings or royals. Response behaviors useful for visitors to assess their impact on penguins include vigilance (repeated rapid head turning) in all 3 species, agonism in king and royal penguins (reaching and striking at conspecifics), and low threat-display (bill

pointing) in gentoo penguins. This study is valuable for wildlife managers as it provides practical information in the application of on-ground visitor guidelines.

Keywords: bird, Australia, beach, grassland, hiking

Holmes, N., M. Giese, and L. K. Kriwoken. 2005. Testing the minimum approach distance guidelines for incubating Royal penguins *Eudyptes schlegeli*. *Biological Conservation* **126**:339–350.

Minimum approach distance guidelines are common tools to maintain a buffer between breeding seabirds and human activity, with the goal of mitigating potentially harmful impacts from these interactions. We employed an experimental design to measure the heart rate and behaviour of Royal penguins on Macquarie Island, Australia, in response to a single pedestrian visit using the current recommended approach distance of 5 m for visitors. Penguins showed increased heart rate (1.23 times average resting heart rate) and vigilance (six-fold increase), suggested to be a precursor to a flight or fight response, however, no penguins fled their nests. These responses were significantly greater than observed during Subantarctic skua overflights, suggesting incubating Royal penguins viewed a single pedestrian at 5 m as a greater threat than a predator overflight. Single persons using the current minimum approach guideline when visiting incubating Royal penguins appear unlikely to elicit responses considered greater than minor or transitory, consistent with activities that are considered acceptable by current management arrangements on Macquarie Island. However, applying this guideline requires caution because the cumulative impacts of visitation are unknown and greater responses may occur with larger group sizes or during different breeding phases. We consider minimum approach distance guidelines should be based on the separation distance necessary to allow animals to undertake normal activity, rather than on the distance people can approach wildlife before the animals flee.

Keywords: bird, Australia, beach, grassland, hiking, wildlife viewing (land)

Hsu, C., C. Chen, and H. Hsieh. 2009a. Effects of sediment compaction on macroinfauna in a protected coastal wetland in Taiwan. *Marine Ecology Progress Series* **375**:73–83.

We examined the effects of recreational trampling on wetland sediments, saltmarshes, and macroinfauna in November 2006 and April and July 2007. We used penetration resistance to measure sediment compaction at the Kaomei wetland, a protected intertidal coastal wetland harboring the largest tuberous bulrush marsh grass bed in Taiwan. We also examined the relationship of sediment compaction to visitor intensity and distribution of macroinfauna. Four compaction levels (low, medium-low, medium-high, and high) were identified using hierarchical cluster analysis. The spatial contour of sediment compaction was consistent with the level of visitor intensity, suggesting that human trampling is the main cause of sediment compaction in this wetland. Macroinfaunal abundance in low and medium-low compacted sediments was 4968 and 3376 ind. m⁻², while no macroinfauna was recorded in highly consolidated sediments. Compared to those at medium-low compaction, taxon richness and community density at medium-high compaction were significantly reduced by 80.5 and 52.6%, respectively. Polychaetes were more sensitive to sediment compaction than amphipods and bivalves, and could thus serve as a bioindicator of human trampling impact. A decrease in polychaete abundance may be attributed to their life history, which is controlled by substratum compaction. Our results showed that 25.7% of the study area was significantly compressed and that muddy vegetated areas were more vulnerable than sandy areas. We conclude that losses of macroinfauna and microhabitats are serious, and we propose management strategies to prevent further deterioration of this wetland.

Keywords: invertebrate, Taiwan, marine, wetland

Hsu, M. J., C.-C. Kao, and G. Agoramoorthy. 2009b. Interactions between visitors and Formosan macaques (*Macaca cyclopis*) at Shou-Shan Nature Park, Taiwan. *American Journal of Primatology* 71:214–222.

Ecotourism involving feeding wildlife has raised public attention and is a controversial issue, especially concerning nonhuman primates. Between July 2002 and April 2005, the behavior of monkeys and tourists was collected through scan samplings, focal samplings and behavior samplings at the Shou-Shan Nature Park located in Taiwan's second largest city—Kaohsiung. In addition, the number of tourists and monkeys was counted in different hours and places within the park. Four hundred visitors were interviewed using a questionnaire to gather data on sex, age, purpose and frequency of visit to the park. The number of tourists was significantly higher during weekends than in weekdays in all locations. Humans dominated in the initiation of interspecies interactions—the overall ratio of human-initiated and monkey-initiated interactions was 2.44:1. Human–monkey conflicts accounted for only 16.4% of the total interactions (n=2,166), and adult human males and adult male macaques participated in higher rates than other age/sex groups in these conflicts. Visitors showed more affiliative behavior (15.9%) than agonistic behavior (8%) toward the macaques. In response to visitors' threat or attack, the Formosan macaques mostly showed submissive behavior with bared teeth, squealed or ran away to avoid confrontation (69.1%)—only few responded with counteraggression (18.7%). This study for the first time provided evidence that food provisioning increased both the frequency and duration of aggression among Formosan macaques ($P < 0.001$). During food provisioning, the average frequency and the duration of agonistic events of macaques were more than 4 times higher compared with those without food provisioning. The average frequency of food provision by tourists was 0.73 times/hr—more than twice the incident that monkeys grabbed the food from tourists (0.34 times/hr). If people refrain from feeding monkeys and destroying the city park's natural vegetation, monkeys can be used to educate public about nature conservation in an urban setting.

Keywords: mammal, Taiwan, forest, urban, hiking, wildlife viewing (land), wildlife feeding

Hulbert, I. A. R. 1990. The response of Ruddy Shelduck *tadorna ferruginea* to tourist activity in the Royal Chitwan National Park of Nepal. *Biological Conservation* 52:113–123.

In a study of the effect of tourist canoes on the distribution and daily activity of ruddy shelduck *Tadorna ferruginea* wintering on the River Rapti in Nepal, the number of ruddy shelduck was found to be unaffected by the canoes. The average length of time a bird was disturbed each day was 11 min. This represented 2.6% of the time spent on total daily activities. Canoes filled with tourists on the downstream journey were responsible for 26% of the total time disturbed, but on the return journey when the empty canoes had to be hauled back upstream, they were responsible for 74% of the total time disturbed. Disturbance, although very small, could be reduced further if the canoes returned in convoy on the northern side of the river.

Keywords: bird, Nepal, freshwater, boating

Ikuta, L. A., and D. T. Blumstein. 2003. Do fences protect birds from human disturbance? *Biological Conservation* 112:447–452.

Outdoor recreation and ecotourism are becoming increasingly popular, but such human activities are not entirely benign to birds. One way to manage wildlife habitats is to restrict public access with a fence or some similar barrier, under the assumption that this provides wildlife with a refuge from human activities. We tested this assumption by measuring the responses of 10 species of birds at a site containing a fence with a relatively large number of visitors on only one side. We compared these responses to those at a less-visited, control site. Responses were measured by quantifying flight initiation distance (FID), the distance birds would allow a human to approach before fleeing. Overall, we found birds on the protected side of the fence responded similarly to birds at the low visitation control site, and significantly differently from birds at the high visitation site. Our results suggest that by reducing the number of humans and providing areas of refuge within highly visited habitats, protective barriers allow birds to behave as they would in an undisturbed environment.

Keywords: bird, United States, wetland, hiking

Ilarri, M. D. I., A. T. de Souza, P. R. de Medeiros, R. G. Gempel, and I. M. de L. Rosa. 2008. Effects of tourist visitation and supplementary feeding on fish assemblage composition on a tropical reef in the Southwestern Atlantic. *Neotropical Ichthyology* 6:651–656.

The effects of tourist visitation and food provisioning on fish assemblages were assessed by visual censuses (stationary technique) carried out in a tropical reef in Northeastern Brazil. Comparisons of species abundance, richness, equitability, and trophic structure in the presence (PT) and absence (AT) of tourists suggest that tourist visitation and supplementary food influenced the structure of the fish assemblage, as follows: (a) diversity, equitability and species richness were significantly higher on the AT period, while the abundance of a particular species was significantly higher during PT; (b) trophic structure differed between the AT and PT periods, omnivores being more abundant during the latter period, while mobile invertivores, piscivores, roving herbivores and territorial herbivores were significantly more abundant on AT. Reef tourism is increasingly being regarded as an alternative to generate income for human coastal communities in the tropics. Therefore, closer examination of the consequences of the various components of this activity to reef system is a necessary step to assist conservation and management initiatives.

Keywords: fish, Brazil, marine, swimming/diving, wildlife feeding

Illich, I. P., and J. R. Haslett. 1994. Responses of Assemblages of Orthoptera to Management and Use of Ski Slopes on Upper Sub-Alpine Meadows in the Austrian Alps. *Oecologia* 97:470–474.

The Orthoptera assemblages occurring on sub-alpine ski slopes were compared with those found on neighbouring unskied meadows by making frequent transect counts at two pairs of sites in the Gastein valley in the Austrian Central Alps. On one of the ski slopes no Orthoptera were present, although two species were abundant on the control meadow a few meters away. On the second ski slope, the Orthoptera assemblage exhibited reduced species richness, lower densities of individuals and a generally accelerated rate of nymphal development compared to the control meadow populations. These results may be explained in terms of the changed habitat conditions on the ski slopes and the known biologies of the species concerned. The implications of the findings for winter tourism management in high altitude ecosystems are briefly discussed.

Keywords: invertebrate, Austria, alpine ski/snowboard

Iverson, J. B., S. J. Converse, G. R. Smith, and J. M. Valiulis. 2006. Long-term trends in the demography of the Allen Cays Rock Iguana (*Cyclura cychlura inornata*): Human disturbance and density-dependent effects. *Biological Conservation* **132**:300–310.

Allen Cays Rock Iguanas (*Cyclura cychlura inornata*) are native to two small islets (Leaf and U Cay) in the north-central Bahamas. These populations were nearly extirpated in the early 1900s because of heavy hunting pressure (for food), but increased to a total of ca. 150 lizards in 1970, and now number over 500 (not including juveniles). Over the past several decades poaching has declined, but tourist visitation (including nearly daily supplemental feeding of iguanas) has increased. To examine human impacts on the demography of these iguanas, survival, population growth rates, and population sizes for subadult and adult (>25 cm snout-vent length) males and females on the two cays were estimated based on mark–recapture data collected over a 25-year period (1980–2004). As predicted, annual survival probability was higher on U Cay (with less human visitation) than on Leaf Cay, was higher in females than in males (which are bolder), and exhibited a declining trend. Both populations more than doubled during this study, but population growth rates declined to near zero in recent years. These data reflect the importance of human impacts, but also suggest that the populations may be nearing carrying capacity. The rapid population growth observed on these cays, and that seen for several other translocated iguana populations, suggest that if unnatural causes of mortality are reduced or eliminated, island populations of iguanas are capable of rapid recovery. The inexpensive establishment of assurance colonies on undisturbed “islands” should be considered for any comprehensive management plan for endangered species of iguanas.

Keywords: reptile, Bahamas, beach, shoreline, wildlife feeding, wildlife viewing (land)

Jayakody, S., A. M. Sibbald, I. J. Gordon, and X. Lambin. 2008. Red deer *Cervus elephus* vigilance behaviour differs with habitat and type of human disturbance. *Wildlife Biology* **14**:81–91.

Red deer *Cervus elaphus*, even in wilderness areas, are increasingly exposed to disturbance from human recreation as well as hunting, and it has been suggested that both types of disturbance may be perceived as a predation risk. We studied the vigilance behaviour of red deer in the Scottish Highlands, in sites with traditionally high numbers of visitors (‘disturbed’) and sites with relatively few visitors (‘less-disturbed’) during the main recreational season (spring and summer), and in their mating grounds during the hunting season (autumn and winter). We carried out direct observations, using scan sampling at 3-minute intervals for 1-hour periods, and recorded the number of animals in each group that were vigilant and their mode of vigilance. During the recreational season, in both the disturbed and less-disturbed sites, data were collected in habitats with different levels of cover (grassland, heather and woodland). The percentage of animals that were vigilant was higher in disturbed than in less-disturbed sites, and higher in disturbed grassland (poor cover) and heather (intermediate cover) than in disturbed woodland (good cover). The majority of the vigilant animals in disturbed heather and woodland habitats and in all the less-disturbed habitats were standing. In disturbed grassland, however, lying was the main posture whilst vigilant. In both disturbed grassland and heather, the percentage of vigilant animals that were moving was higher than in woodland or the less-disturbed habitats. In disturbed sites, the deer were more likely to be aggregated when vigilance levels were high. During the hunting season, the overall level of vigilance was higher than at any sites during the recreational season, and the majority of vigilant animals were moving. We conclude that red deer respond to disturbance from human recreational activities by increasing their level of vigilance, but that the nature of their response varies with the level of cover available. We suggest that red deer may lie down when keeping vigil in grasslands, because lying animals are less conspicuous and the low cover will still allow animals to scan

their surroundings. We conclude that, although they respond to both types of disturbance by increasing vigilance, red deer perceive human recreation as a less acute threat than hunting.

Keywords: mammal, United Kingdom, forest, grassland, scrub/shrub, hiking, dog-walking

Jayakody, S., A. M. Sibbald, R. W. Mayes, R. J. Hooper, I. J. Gordon, and L. Xavier. 2011. Effects of human disturbance on the diet composition of wild red deer (*Cervus elaphus*). *European Journal of Wildlife Research* **57**:939–948.

Disturbance from human recreational activities may affect the nutrition of free-ranging herbivores due to trade-offs between feeding in preferred habitats and perceived predation risk. To test this hypothesis, we estimated diet composition for red deer in the Scottish highlands in spring, when recreational activity tends to be high, and in winter when it is lower. We analysed faecal samples from three habitat types (grassland, heather moorland and woodland) collected at sites close to a busy track (disturbed) and at a distance from it (less disturbed). The diet consisted of 39% grasses, sedges, herbs and rushes (GSHR) and 58% *Calluna vulgaris* and *Erica* spp. (heather) in spring, compared with 14% grasses and 77% heather in winter, with small quantities of *Vaccinium* spp. (berry) and *Pinus sylvestris* (tree) in both seasons. In spring, faeces from disturbed grass and woodland sites indicated a diet with less GSHR and more heather and tree than faeces from less-disturbed sites, which could be due to an increased need for vigilance in exposed grassland and the need to seek cover. In contrast, faeces from all disturbed sites in winter indicated a diet with more GSHR and less heather than faeces from less-disturbed sites. This could be due to a seasonal decline in recreation and increase in hunting activity reversing the disturbance levels at the different sites, since hunting is not normally carried out in areas used by the public for recreation. We conclude that there may be nutritional benefits to deer of reducing disturbance near open grassland.

Keywords: mammal, United Kingdom, grassland, scrub/shrub, dog-walking, hiking

Jiménez, G., J. A. Lemus, L. Meléndez, G. Blanco, and P. Laiolo. 2011. Dampened behavioral and physiological responses mediate birds' association with humans. *Biological Conservation* **144**:1702–1711.

The study of the mechanisms involved in phenotypic adaptations or plasticity to environmental stressors may serve to evaluate contemporary ecological and evolutionary dynamics in threatened or growing wildlife populations. By addressing human disturbance as a main stressor agent, we investigated antipredator response (flushing distance), social behavior (degree of gregarism), health (fecal pathogens), and endocrine status (fecal corticosterone levels) as potential mechanisms that permit birds to cope with anthropogenic impact in tourist areas. Our study models were species that are neither urbanized nor invasive, and that are typical of the high mountains of the Palearctic: the Alpine and the Red-billed chough (*Pyrrhocorax graculus* and *P. pyrrhocorax*), and the surrounding alpine bird community. Both chough species showed habituation, reduced flushing distances, fewer parasites and lower corticosterone levels in tourist than in non-tourist sites, and a significant variation in gregarious behavior. Behavioral and physiological adjustments permitted these corvids to optimize resource exploitation depending on habitat quality and in conditions of continuous disturbance. Human-induced changes in chough social behavior had no effect on local avian species richness, a surrogate measure for community diversity. Irrespectively of chough aggregations, bird diversity decreased significantly in recreational areas, thus not all community members tolerated human impact as choughs did. Our findings suggest that species that manage to coexist with humans primarily adjust traits that influence ecological

interactions (social, foraging or antipredatory responses) and that vary rapidly (learned behaviors and physiological mechanisms that promote homeostasis)

Keywords: bird, Spain, agricultural, forest, scrub/shrub, hiking

Kaiser, M. S., and E. K. Fritzell. 1984. Effects of River Recreationists on Green-Backed Heron Behavior. *The Journal of Wildlife Management* **48**:561–567.

No abstract

Keywords: bird, United States, freshwater, boating

Kangas, K., M. Luoto, A. Ihanola, E. Tomppo, and P. Siikamäki. 2010. Recreation-induced changes in boreal bird communities in protected areas. *Ecological Applications* **20**:1775–1786.

The impacts of human-induced disturbance on birds have been studied in growing extent, but there are relatively few studies about the effects of recreation on forest bird communities in protected areas. In this paper, the relative importance of recreation as well as environmental variables on bird communities in Oulanka National Park, in northeastern Finland, was investigated using general additive models (GAM). Bird data collected using the line transect method along hiking trails and in undisturbed control areas were related to number of visits, area of tourism infrastructure, and habitat variables. We further examined the impact of spatial autocorrelation by calculating an autocovariate term for GAMs. Our results indicate that number of visits affects the occurrence and composition of bird communities, but it had no impact on total species richness. Open-cup nesters breeding on the ground showed strongest negative response to visitor pressure, whereas the open-cup nesters nesting in trees and shrubs were more tolerant. For cavity-nesting species, recreation had no significant impact. The contribution of the number of visits was generally low also in models in which it was selected, and the occurrence of birds was mainly determined by habitat characteristics of the area. However, our results show that the recreation-induced disturbance with relatively low visitor pressure can have negative impacts on some bird species and groups of species and should be considered in management of protected areas with recreational activities

Keywords: bird, Finland, forest, wetland, hiking

Karp, D. S., and R. Guevara. 2011. Conversational Noise Reduction as a Win–Win for Ecotourists and Rain Forest Birds in Peru. *Biotropica* **43**:122–130.

For all its positive attributes, the recent expansion of ecotourism has resulted in greater influxes of people into natural areas, causing a range of impacts including behavioral disruptions among wildlife. How animals respond to conversation is poorly understood, but noise reduction may reduce the impact of ecotourists while simultaneously enhancing their experience with higher wildlife encounter rates. We tested the response of a rain forest bird community to noise by playing a recorded conversation while conducting point censuses in a terra firme forest in Tambopata, Peru. Fifty decibel conversation (approximately library speaking volume) caused declines of 35 percent in total detections and 33 percent in detected species richness. Birds reacted similarly to 60 dB (approximately the volume of an excited child): average detections declined by 39 percent and detected species richness by 37 percent. Specifically, noise-induced detection declines were manifest both in decreased vocalizations (37% decline) and decreased physical sightings (44% decline). Lowered detection

frequencies indicate behavioral shifts. As vocalization is involved in territory defense, breeding behavior, and predator detection, strong noise responsiveness indicates potential harm for birds. Insectivores were the most affected bird guild, raising conservation concerns, as insectivorous birds are sensitive to habitat modification. Birds reacted strongly to noise both near an established ecotourist lodge and in an intact reserve, indicating an absence of habituation. Thus, as a method for reducing ecotourism's footprint on native fauna and improving tourist satisfaction with increased wildlife sightings, noise reduction seems promising, even for well-established ecotourist lodges.

Keywords: bird, Peru, forest

Karp, D. S., and T. L. Root. 2009. Sound the stressor: how Hoatzins (*Opisthocomus hoazin*) react to ecotourist conversation. *Biodiversity and Conservation* **18**:3733–3742.

Exposure to ecotourists often disrupts animal behavior, which is known to contribute to heightened mortality rates. In the Amazon, the emblematic, communal nesting Hoatzin (*Opisthocomus hoazin*) is frequently pursued by tourists eager for close views. Such encounters may cause heightened stress levels, and egg or nestling predation due to decreased parental attendance to nests and nestlings. The effect of reducing conversational tourist noise near wildlife is poorly understood, but represents one potential mechanism of mitigating the impacts of ecotourists on wildlife. In this study, we approached Hoatzins by canoe, playing recorded tourist conversations at different volumes. Both the distances from which we observed Hoatzins becoming agitated (e.g., clucking, defecation, etc.) and flush (e.g., flight or climbing away) were positively correlated with volume. Within 10 weeks Hoatzins began to habituate to silent approaches. Tourist conversations, however, continued to elicit the same heightened disturbance responses throughout data collection. Therefore, to have the best chance of seeing Hoatzins at a short distance and minimizing potentially negative disturbances, ecotourists should cease all conversation. Although not tested, silence is probably the best strategy when looking for many wildlife species.

Keywords: bird, Peru, forest, freshwater, boating

Keeley, W. H., and M. J. Bechard. 2011. Flushing Distances of Ferruginous Hawks Nesting in Rural and Exurban New Mexico. *Journal of Wildlife Management* **75**:1034–1039.

As natural environments become increasingly modified by humans, land managers should devise plans to protect sensitive species from human activities that disturb these species. We explored behavioral responses of nesting ferruginous hawks (*Buteo regalis*) to an approaching human in areas where the level of human activity on the landscaped varied. Contrary to other reports, hawks were aggressive in nest defense and female hawks defended nests more aggressively than male hawks. Adult hawks decreased nest defense intensity as nestling age increased but increased intensity with consecutive human visits to the nest. Flushing distance was considerably higher than that documented in other studies and was negatively related to degree of urbanization. We found that a distance of 650 m prevented 95% of nest-attending ferruginous hawks from flushing in response to human intruders; thus we recommend establishing a spatial buffer of this distance or greater to minimize adverse effects of human activities on hawks nesting in New Mexico.

Keywords: bird, United States, grassland, urban, hiking

Keller, V. E. 1991. Effects of human disturbance on Eider ducklings *Somateria mollissima* in an estuarine habitat in Scotland. *Biological Conservation* **58**:213–228.

Eider ducklings *Somateria mollissima* on the Ythan estuary in Scotland were frequently disturbed by recreational activities, both when roosting on the shore and when feeding in the water. Shore-based activities (fishermen, people walking along the shore, dogs) caused more disturbances than water-based ones (windsurfers, rowing boats). Disturbance affected the activity of eider creches for up to 35 min. Disturbance of small ducklings led to an increase in predator encounters during the five minutes following the disturbance.

Keywords: bird, United Kingdom, fishing (shore), hiking, dog-walking, boating

Kerbiriou, C., I. Le Viol, A. Robert, E. Porcher, F. Gourmelon, and R. Julliard. 2009. Tourism in protected areas can threaten wild populations: from individual response to population viability of the chough *Pyrrhocorax pyrrhocorax*. *Journal of Applied Ecology* **46**:657–665.

* 1Many protected areas are now faced with increasing pressure from visitors and tourism development. There is thus an urgent need for conservation biologists to evaluate the full impact of human disturbance not only on individual responses, but also on the viability of protected populations, so that relevant management measures can be proposed. * 2We studied the impact of tourism on the rare and endangered chough *Pyrrhocorax pyrrhocorax* on a protected French island to assess the relationship between visitor pressure, bird individual behaviour and fitness, and population viability. During 8 years, we monitored foraging behaviour and estimated monthly juvenile survival using mark–recapture data. Population viability was examined under different tourism scenarios, using a stochastic individual-based model that incorporated the impact of visitor numbers on juvenile survival. * 3In summer, the foraging probability of choughs was negatively correlated with the number of visitors. As a result, the time allocated to foraging during peak tourist season, adjusted to day length and prey availability, was 50% lower than expected. * 4Juvenile survival rates were lowest in August, the peak tourist season, and varied significantly across years. August survival rate and therefore annual survival were negatively correlated with the number of visitors on the island in August and, except for a minor negative effect of rainfall, were not influenced by other environmental variables. * 5Stochastic simulations predicted a low probability of extinction of the protected population if the number of visitors remains constant in the future. However, short-term viability would be dramatically reduced if the current rate of increase in visitor numbers is maintained. * 6Synthesis and applications. We show that a relatively minor human-induced disturbance (e.g. scaring individuals away) has dramatic effects on population viability in a protected area, even when breeding individuals are not directly affected. This suggests that the full impact of tourism in protected areas may be overlooked, and has direct consequences for the assessment of sustainable levels of human disturbance and the design of quantitative management options compatible with tourist activities in protected areas. We specifically emphasize the need for more integrative approaches combining research at individual and population levels.

Keywords: bird, France, grassland, marine, shoreline, hiking

King, J. M., and J. T. Heinen. 2004. An assessment of the behaviors of overwintering manatees as influenced by interactions with tourists at two sites in central Florida. *Biological Conservation* **117**:227–234.

We used a combination of focal animal and scan samples over the course of two winter seasons to assess behavioral patterns of manatees as a function of the presence and activities of recreational swimmers and boats

in and around Crystal River National Wildlife Refuge, Florida. The nature and outcome of human–manatee interactions and the frequency of harassment of manatees by swimmers (as defined by the US Fish and Wildlife Service) were also recorded. The use of protected (no-entry) sanctuaries by manatees was significantly greater when both the numbers of swimmers and boats increased, and when water temperatures were lower in surrounding areas. The time manatees spent bottom-resting and nursing decreased while the time spent milling and swimming increased when swimmers were present compared with when they were absent. Over half of the direct interactions recorded between swimmers and manatees constituted some form of harassment as defined by Refuge guidelines, and manatees were far more likely to terminate these interactions than were swimmers. We conclude that the existence of no-entry sanctuaries is very important for the conservation of manatees in the area and thought must be given to expanding the sanctuary network. Furthermore, additional efforts at enforcement and public education are needed. We address, qualitatively, several potential management options to better-secure manatees at this critical time of the year.

Keywords: mammal, United States, freshwater, marine, boating, swimming/diving

Klailova, M., C. Hodgkinson, and P. C. Lee. 2010. Behavioral responses of one western lowland gorilla (*Gorilla gorilla gorilla*) group at Bai Hokou, Central African Republic, to tourists, researchers and trackers. *American Journal of Primatology* 72:897–906.

Gorilla tourism, widely perceived as a lucrative industry, is propelled by strong market demand with programs in five countries and for three of four gorilla subspecies. Human presence may negatively affect wild gorillas, potentially lowering immunity and increasing the likelihood of acquiring human-borne disease. Yet, behavioral impacts of humans on wild gorilla behavior remain largely unexplored, particularly for western lowland gorillas. We evaluate the impact of tourist presence, human observer numbers (tourists, trackers, and researchers), and human observer distance on the behavior of one habituated gorilla group at Bai Hokou, Central African Republic. Behavioral data were collected for more than 12 months from January 2007. Of silverback aggressive events, 39% (N=229) were human directed, but 65% were low-level soft barks. Adult females, and one in particular, were responsible for the highest number of aggressive events toward humans. Humans maintained closer proximity to the silverback when tourists were present, although tourist numbers had no significant impact on overall group activity budgets or rates of human-directed aggression. However, as research team size increased, group feeding rates decreased. Close observer–silverback distance correlated with a decrease in his feeding rates and an increase in human monitoring. He directed less aggression toward observers at distances >10 m, although observers spent 48.5% of time between 6 and 10 m of the silverback. We discuss gorilla personality as a factor in human-directed aggression. We explore whether the current 7 m distance limit governing gorilla tourism, based on disease transmission risks, is sufficient considering the potential behavioral stressor of close human presence. We recommend increasing minimum observation distance to >10 m where possible, decreasing observer group sizes, particularly after a visit consisting of maximum numbers and restricting tourist access to 1 visit/day. *Am. J. Primatol.* 72:897–906, 2010. © 2010 Wiley-Liss, Inc.

Keywords: mammal, Central African Republic, forest, wildlife viewing (land)

Klein, M. L., S. R. Humphrey, and H. F. Percival. 1995. Effects of Ecotourism on Distribution of Waterbirds in a Wildlife Refuge. *Conservation Biology* 9:1454–1465.

Humans visiting natural areas often disturb wildlife, possibly displacing animals from desirable habitat. To hold ecotourism at acceptable levels refuge managers need to know which species are likely to be affected and which response occurs at different levels of disturbance. Displacement of waterbirds at J. N. "Ding" Darling National Wildlife Refuge, Florida (U.S.A.), by specific human activities was demonstrated experimentally by Klein in 1993. We assessed the extent of this effect of ecotourism on the distribution of 38 species of waterbirds by surveying birds in plots of known distance from a dike along which wildlife tours occurred. Most resident species were less sensitive to disturbance than were migrants. Migrant ducks were most sensitive when they first arrived, mid-October to mid-December, usually remaining more than 80 m from the drive, even at low levels of human visitation. Herons, egrets, Brown Pelicans (*Pelecanus occidentalis*), and Anhingas (*Anhinga anhinga*) were most likely to remain close to areas of high human activity. Shorebirds were displaced at intermediate distance and visitation levels. Mottled Ducks (*Anas fulvigula*) and several of the ardeids seemed to include two groups differing in behavior, one habituated to humans and one sensitive to disturbance. Public education and changes in management practices are needed to reduce disturbance. Guided tours and low-disturbance zones where people stay in their cars could reduce the negative effects of tourists, especially in the fall when migrants arrive. The number of human visitors may have to be reduced or the wildlife drive closed on certain days during the tourist season.

Keywords: bird, United States, wetland, hiking, wildlife viewing (land)

Krebs, J., E. C. Lofroth, and I. Parfitt. 2007. Multiscale Habitat Use by Wolverines in British Columbia, Canada. *Journal of Wildlife Management* 71:2180–2192.

Wolverine (*Gulo gulo*) distribution in British Columbia, Canada, includes multiple-use lands where human use and resource extraction may influence habitat selection. We evaluated seasonal habitat use by resident adult wolverines using radiotelemetry locations from 2 multiple-use landscapes in British Columbia. Food, predation risk, and human disturbance hypotheses were considered in logistic regression analyses of used and random landscapes. Male wolverine habitat associations were most supported by the food hypothesis in both summer and winter. Moose (*Alces alces*) winter ranges, valley bottom forests, and avalanche terrain were positively associated with winter male wolverine use. Habitat use by male wolverines in winter was also negatively associated with helicopter skiing areas in the Columbia Mountains. Habitat associations of females were more complex; combinations of variables supporting food, predation risk, or human disturbance hypotheses were included in most supported models from both summer and winter in both study areas. Females were associated with alpine and avalanche environments where hoary marmot (*Marmota caligata*) and Columbia ground squirrel (*Spermophilus columbianus*) prey are found in summer. Roaded and recently logged areas were negatively associated with female wolverines in summer. In the Columbia Mountains, where winter recreation was widespread, females were negatively associated with helicopter and backcountry skiing. Moose winter ranges within rugged landscapes were positively associated with females during winter. Our analysis suggests wolverines were negatively responding to human disturbance within occupied habitat. The population consequences of these functional habitat relationships will require additional focused research. Our spatially explicit models can be used to support conservation planning for resource extraction and tourism industries operating in landscapes occupied by wolverines.

Keywords: mammal, Canada, forest, grassland, tundra, alpine ski/snowboard, motorized (land)

Lafferty, K. D. 2001a. Birds at a southern California beach: Seasonality, habitat use and disturbance by human activity. *Biodiversity and Conservation* 10:1949–1962.

Use of a Santa Barbara beach by people and birds varied in both time and space. There were 100 birds, 18 people and 2 dogs per kilometer. Bird density varied primarily with the season and tide while human activity varied most between weekend and weekday. Bird distributions along the beach were determined mainly by habitat type (particularly a lagoon and exposed rocky intertidal areas). For crows and western gulls, there was some evidence that access to urban refuse increased abundance. Interactions between birds and people often caused birds to move or fly away, particularly when people were within 20 m. During a short observation period, 10% of humans and 39% of dogs disturbed birds. More than 70% of birds flew when disturbed. Bird species varied in the frequency that they were disturbed, partially because a few bird species foraged on the upper beach where contact with people was less frequent. Most disturbances occurred low on the beach. Although disturbances caused birds to move away from humans, most displacement was short enough that variation in human activity did not alter large-scale patterns of beach use by the birds. Birds were less reactive to humans (but not dogs) when beach activity was low.

Keywords: bird, United States, beach, beach use, dog-walking, hiking, jogging/running

Lafferty, K. D. 2001b. Disturbance to wintering western snowy plovers. *Biological Conservation* **101**:315–325.

In order to better understand the nature of disturbances to wintering snowy plovers, I observed snowy plovers and activities that might disturb them at a beach near Devereux Slough in Santa Barbara, California, USA. Disturbance (activity that caused plovers to move or fly) to wintering populations of threatened western snowy plovers was 16 times higher at a public beach than at protected beaches. Wintering plovers reacted to disturbance at half the distance (~40 m) as has been reported for breeding snowy plovers (~80 m). Humans, dogs, crows and other birds were the main sources of disturbance on the public beach, and each snowy plover was disturbed, on average, once every 27 weekend min and once every 43 weekday min. Dogs off leash were a disproportionate source of disturbance. Plovers were more likely to fly from dogs, horses and crows than from humans and other shorebirds. Plovers were less abundant near trail heads. Over short time scales, plovers did not acclimate to or successfully find refuge from disturbance. Feeding rates declined with increased human activity. I used data from these observations to parameterize a model that predicted rates of disturbance given various management actions. The model found that prohibiting dogs and a 30 m buffer zone surrounding a 400 m stretch of beach provided the most protection for plovers for the least amount of impact to beach recreation.

Keywords: bird, United States, beach, dog-walking, hiking, jogging/running, beach use

Lafferty, K. D., D. Goodman, and C. P. Sandoval. 2006. Restoration of Breeding by Snowy Plovers Following Protection from Disturbance. *Biodiversity and Conservation* **15**:2217–2230.

Promoting recreation and preserving wildlife are often dual missions for land managers, yet recreation may impact wildlife. Because individual disturbances are seemingly inconsequential, it is difficult to convince the public that there is a conservation value to restricting recreation to reduce disturbance. We studied threatened western snowy plovers (*Charadrius alexandrinus nivosus*) at a public beach (Sands Beach, Coal Oil Point Reserve) in Santa Barbara, California (USA) before and during a period when a barrier directed foot traffic away from a section of upper beach where snowy plovers roost. The barrier reduced disturbance rates by more than half. Snowy plovers increased in abundance (throughout the season) and their distribution contracted to

within the protected area. Snowy plovers that were outside the protected area in the morning moved inside as people began using the beach. Experiments with quail eggs indicated an 8% daily risk of nest trampling outside the protected area. Before protection, plovers did not breed at Coal Oil Point. During protection, snowy plovers bred in increasing numbers each year and had high success at fledging young. These results demonstrate how recreational disturbance can degrade habitat for shorebirds and that protecting quality habitat may have large benefits for wildlife and small impacts to recreation.

Keywords: bird, United States, beach, beach use

Lamb, J. B., and B. L. Willis. 2011. Using coral disease prevalence to assess the effects of concentrating tourism activities on offshore reefs in a tropical marine park. *Conservation Biology* **25**:1044–1052.

Concentrating tourism activities can be an effective way to closely manage high-use parks and minimize the extent of the effects of visitors on plants and animals, although considerable investment in permanent tourism facilities may be required. On coral reefs, a variety of human-related disturbances have been associated with elevated levels of coral disease, but the effects of reef-based tourist facilities (e.g., permanent offshore visitor platforms) on coral health have not been assessed. In partnership with reef managers and the tourism industry, we tested the effectiveness of concentrating tourism activities as a strategy for managing tourism on coral reefs. We compared prevalence of brown band disease, white syndromes, black band disease, skeletal eroding band, and growth anomalies among reefs with and without permanent tourism platforms within the Great Barrier Reef Marine Park. Coral diseases were 15 times more prevalent at reefs with offshore tourism platforms than at nearby reefs without platforms. The maximum prevalence and maximum number of cases of each disease type were recorded at reefs with permanently moored tourism platforms. Diseases affected 10 coral genera from 7 families at reefs with platforms and 4 coral genera from 3 families at reefs without platforms. The greatest number of disease cases occurred within the spatially dominant acroporid corals, which exhibited 18-fold greater disease prevalence at reefs with platforms than at reefs without platforms. Neither the percent cover of acroporids nor overall coral cover differed significantly between reefs with and without platforms, which suggests that neither factor was responsible for the elevated levels of disease. Identifying how tourism activities and platforms facilitate coral disease in marine parks will help ensure ongoing conservation of coral assemblages and tourism.

Keywords: invertebrate, Australia, marine, swimming/diving

Laroche, R. K., A. A. Kock, L. M. Dill, and W. H. Oosthuizen. 2007. Effects of provisioning ecotourism activity on the behaviour of white sharks *Carcharodon carcharias*. *Marine Ecology Progress Series* **338**:199–209.

Ecotourism operations which provide food to large predators have the potential to negatively affect their target species, by conditioning them to associate humans with food, or by generally altering their behavioural patterns. This latter effect could have potentially detrimental consequences for the ecosystem inhabited by the predator, because any behavioural changes could affect the species with which they interact. We present the results of an experimental study conducted from June to October 2004, which examined the effects of provisioning ecotourism on the behaviour of white sharks around a seal colony on a small island in South Africa. Although ecotourism activity had an effect on the behaviour of some sharks, this was relatively minor, and the majority of sharks showed little interest in the food rewards on offer. It is unlikely that conditioning would occur from the amount of ecotourism activity tested, because even those sharks identified supplying

most of the data presented here (which may be more strongly predisposed towards conditioning, as their persistence around the boat is what allowed them to be identified) showed a nearly ubiquitous trend of decreasing response with time. Furthermore, even the sharks frequently acquiring food rewards typically stopped responding after several interactions. Consequently, moderate levels of ecotourism probably have only a minor impact on the behaviour of white sharks, and are therefore unlikely to create behavioural effects at the ecosystem level.

Keywords: fish, South Africa, marine, wildlife feeding

Leighton, P. A., J. A. Horrocks, and D. L. Kramer. 2010. Conservation and the scarecrow effect: Can human activity benefit threatened species by displacing predators? *Biological Conservation* **143**:2156–2163.

Most wild animals show direct negative responses to human disturbance; however, disturbance may also have positive indirect effects by altering species interactions. In the Caribbean, introduced mongooses (*Herpestes javanicus*) are an important diurnal predator of the nests of critically endangered hawksbill sea turtles (*Eretmochelys imbricata*). We asked whether daytime visitor activity could benefit hawksbills by reducing mongoose activity in nesting habitat. We used track monitoring sites to measure how mongooses alter their space use in response to fluctuating human beach use and availability of hawksbill nests, and we estimated the indirect impact of human disturbance on nest predation for 5 years of hawksbill nesting. Human activity substantially decreased mongoose use of nesting habitat. Mongoose activity increased with abundance of nests and was lower at the edge than the interior of patches of beach vegetation, but neither factor altered relative sensitivity to disturbance. We estimated that, in addition to deterring mongooses from accessing nests on the open beach, human activity has the potential to reduce predation of nests in vegetation by up to 56% at our site, with the greatest per capita impact at low (<50) visitor numbers. Many forms of human activity negatively affect sea turtles, but our study indicates that there are positive aspects of daytime use of nesting beaches. Optimizing the trade-off between positive and negative impacts of disturbance could provide a useful approach for regulating tourist activity in critical habitat for threatened species.

Keywords: mammal, Barbados, beach, grassland, scrub/shrub, beach use

Lemon, M., T. P. Lynch, D. H. Cato, and R. G. Harcourt. 2006. Response of travelling bottlenose dolphins (*Tursiops aduncus*) to experimental approaches by a powerboat in Jervis Bay, New South Wales, Australia. *Biological Conservation* **127**:363–372.

Powerboats are potentially a significant source of disturbance to coastal cetaceans. Information is scarce, however, on the nature of interactions between powerboats and dolphins, particularly when both surface and acoustic behaviour are combined. The surface behaviour and acoustic response of travelling dolphins to approaches by a powerboat were assessed by a series of experimental trials between November 2001 and November 2003 in Jervis Bay, New South Wales, Australia. Dolphin behaviour was monitored continuously from an independent research boat before, during and after a powerboat approached ($n = 12$). Treatments were interspersed with control observations ($n = 12$). Changes in surface behaviour indicated differences between the treatment and control periods ($z = 2.24$, $p = 0.025$), with dolphins tending to alter their surface behaviour when exposed to the powerboat approach. Analysis also revealed a change in the direction of travel by dolphin groups when approached ($z = 3.22$, $p = 0.001$). Changes in surface behaviour occurred at vessel approach distances outside the minimum approach distance of 30 m for recreational and commercial vessels, as proposed by the New South Wales National Parks and Wildlife Service. In contrast, there were no changes

in dolphin whistle rates ($F_{3,12} = 0.74$, $p = 0.54$) or the duration of echolocation click bouts ($F_{3,12} = 0.76$, $p = 0.59$) when approached. These findings indicate that powerboats do affect the surface behaviour and direction of travelling inshore bottlenose dolphins in Jervis Bay; however it appears that this impact is not reflected in their acoustic behaviour.

Keywords: mammal, Australia, marine, motorized (boat)

Lenth, B. E., R. L. Knight, and M. E. Brennan. 2008. The Effects of Dogs on Wildlife Communities. *Natural Areas Journal* **28**:218–227.

Domestic dogs (*Canis familiaris*) are frequent visitors to protected areas, but little is known about how they affect wildlife communities. We studied the effects of dogs on wildlife communities by comparing the activity levels of wildlife in areas that prohibited dogs with areas that allowed dogs. We measured wildlife activity on trails and up to 200 m away from trails using five methods: (1) pellet plots, (2) track plates, (3) remote triggered cameras, (4) on-trail scat surveys, and (5) mapping prairie dog (*Cynomys ludovicianus*) burrow locations. The presence of dogs along recreational trails correlated with altered patterns of habitat utilization by several species. Mule deer (*Odocoileus hemionus*) activity was significantly lower within 100 m of trails in areas that allowed dogs than in areas that prohibited dogs. Small mammals, including squirrels (*Sciurus* spp.) and rabbits (*Sylvilagus* spp.), also exhibited reduced levels of activity within 50 m of trails in areas that allowed dogs when compared with areas without. The density of prairie dog burrows was lower within 25 m of trails in areas that allowed dogs. The presence of dogs also affected carnivore activity. Bobcat (*Felis rufus*) detections were lower in areas that allowed dogs, and red fox (*Vulpes vulpes*) detections were higher. These findings have implications for the management of natural areas, particularly those that allow dogs to be off-leash.

Keywords: mammal, United States, forest, biking, equestrian, hiking

Lott, D. F., and M. McCoy. 1995. Asian rhinos *Rhinoceros unicornis* on the run? Impact of tourist visits on one population. *Biological Conservation* **73**:23–26.

We evaluated the impact of tourist visits on Asian rhinos *Rhinoceros unicornis* in Chitwan National Park, Nepal, by comparing the rhino's behavior during and after elephant-borne tourist visits to their behavior before visits. During the visits, the rhinos spent more time on alert and less time feeding. Close approaches (especially those under 10 m) were more disruptive, and frequently displaced the rhinos from the meadows where they preferred to feed. Visits were short (20.7 min average) and rhinos that were not driven out re-established their pre-visit pattern of behavior within 14 min of the tourists' departure. Moreover, these rhinos' home ranges overlapped extensively and individuals ranged widely so that each individual's encounters with tourists were usually several days apart. Eliminating close approaches would make these tourist visits relatively benign. However, this finding cannot necessarily be extended to other populations that might have different social systems.

Keywords: mammal, Nepal, wildlife viewing (land)

Lusseau, D. 2003a. Effects of tour boats on the behavior of bottlenose dolphins: using Markov chains to model anthropogenic impacts. *Conservation Biology* **17**:1785–1793.

Abstract: Nature-based tourism activities have been developing over the last decade, but it is still difficult to manage these activities sustainably. This sector is increasingly focusing on whales and dolphins in coastal communities, but the exact effects of these tourism activities are unclear. Markov chain modeling may help researchers assess the effects of tourism activities on the behavioral budget of small cetaceans. Matrix models have been used widely in population ecology to provide successful management guidelines. From June 2000 to August 2001, I collected information on the behavioral state of bottlenose dolphin (*Tursiops* spp.) schools from a population residing in Doubtful Sound, Fiordland, New Zealand. In addition, I recorded the occurrence of boat and dolphin interactions. I then calculated the transition probabilities of passing from one behavior to another by using a first-order, time-discrete Markov chain model. Behavioral transitions during which a boat-dolphin interaction occurred were compiled in an “impact” chain. All other transitions were tallied in a control chain. I then quantified the effect of boat-dolphin interactions during behavioral transitions by comparing the behavioral transition probabilities of both chains. Socializing and resting behaviors were disrupted by interactions with boats to a level that raises concern. Both the duration of bouts and the total amount of time spent in both these behavioral states were substantially decreased. Dolphins were significantly more likely to be traveling after an interaction with a boat. However, the overall behavioral budget of the population was not significantly affected. Therefore, the bottlenose dolphin population seems to be able to sustain the present level of boat interactions because of its low intensity. More effort is needed to develop prognosis analyses in order to understand how the effect of boat interactions on dolphins changes with variations in intensity.

Keywords: mammal, New Zealand, marine, boating, wildlife viewing (boat)

Lusseau, D. 2003b. Male and female bottlenose dolphins *Tursiops* spp. have different strategies to avoid interactions with tour boats in Doubtful Sound, New Zealand. *Marine Ecology Progress Series* **257**:267–274.

I assessed the short-term reactions of bottlenose dolphins *Tursiops* spp. to interactions with tour boats, and their long-term implications. Vertical avoidance of boats, showed by an increase in time spent underwater, is a typical response in cetaceans, and has been likened to predator avoidance strategies. This study looked at the variation in diving pattern of bottlenose dolphins in Doubtful Sound, New Zealand, in relation to boat interactions. An observing vessel was used to collect the data. A regressive approach showed that this vessel did not have a significant effect on the diving pattern of the dolphins. The analysis would have allowed the detection of a small difference (6.35 s) in dive interval (percentage of variance, $PV = 0.05$) with high certainty (power = 0.86). Dolphins avoided tour boats vertically by increasing their mean diving interval. Dolphins started to react before boats were in visual contact. An information theoretic approach indicated that the behaviour of the boat was the predominant factor affecting the diving interval. Males and females responded differently to interactions with boats. Males started to avoid boats as soon as they were present, while females switched to a vertical avoidance strategy only when interactions became intrusive. This difference in avoidance strategy may be related to the different metabolic regime of the sexes. Males would be more likely to meet the cost of vertical avoidance of boats because of their greater energy stores. Females vertically avoid boats, an energetically expensive exercise for them, only when the risk incurred by this interaction is high.

Keywords: mammal, New Zealand, marine, wildlife viewing (boat)

Lusseau, D. 2004. The hidden cost of tourism: detecting long-term effects of tourism using behavioral information. *Ecology and Society* **9**:2.

Increasingly, whales and dolphins are the focus of tourism activities in many coastal locations. Although these activities can affect individuals and populations of cetaceans, the biological significance and hence the cost of these impacts are as yet largely unknown. This study assessed the effects of boat interactions on the behavioral budget of two populations of bottlenose dolphins (*Tursiops truncatus*) living in similar fjords but exposed to different levels of tourism activities. This comparison makes it possible to assess the costs of short-term avoidance strategies and the threshold at which those strategies are no longer effective. The effects of boat interactions were the same in both fjords. The resting state was the most sensitive to interactions; socializing was less sensitive. Short-term displacement was a typical response to boat exposure: dolphins were more likely to travel after an interaction with a vessel. Although the behavioral budgets of these populations were significantly altered during interactions with boats, their overall behavioral budgets were unchanged. Dolphins in Milford Sound actively avoided boat interactions, possibly to maintain their overall behavioral budget unchanged. This active avoidance led to avoidance of the area. Characteristics of dolphin-boat interactions in Milford Sound suggest that the advantages gained by short-term avoidance are lost if, on average, fewer than 68 min elapse between successive interactions with boats. If dolphin-boat interactions were more frequent than this, the dolphins switched to a longer-term response: area avoidance.

Keywords: mammal, New Zealand, marine, wildlife viewing (boat)

Lusseau, D. 2005. Residency pattern of bottlenose dolphins *Tursiops* spp. in Milford Sound, New Zealand, is related to boat traffic. *Marine Ecology Progress Series* **295**:265–272.

A population of bottlenose dolphins inhabits 7 of the 14 fjords that compose Fiordland, New Zealand. One of these fjords, Milford Sound, supports a large tourism industry that results in intense boat traffic. Bottlenose dolphins regularly visited Milford Sound and tour boats interacted with them during these visits. I studied the factors affecting the frequency of visits to Milford Sound by relating the residency pattern of dolphins in this fjord to oceanographic parameters and variations in boat traffic between December 1999 and February 2002. Boat traffic was the only variable that could explain the frequency of dolphin visits to Milford Sound. Dolphins spent less time in Milford Sound during seasons of intense boat traffic. Moreover, when dolphins visited this fjord, they spent more time at the entrance of the fjord when boat traffic was intense, out of the reach of tour boats. It seems that dolphins avoid Milford Sound when traffic is heavy. This avoidance could have long-term implications for the demography of the population.

Keywords: mammal, New Zealand, marine, wildlife viewing (boat)

Lusseau, D. 2006. The Short-Term Behavioral Reactions of Bottlenose Dolphins to Interactions with Boats in Doubtful Sound, New Zealand. *Marine Mammal Science* **22**:802–818.

Doubtful Sound is home to one of the southernmost resident populations of bottlenose dolphins (*Tursiops* sp.). This population regularly interacts with scenic cruises. During these interactions, dolphins tend to horizontally and vertically avoid vessels, especially when the behavior of these vessels is intrusive. This study aimed at understanding the behavioral reactions of individuals to these interactions that lead to the disruption of the school's behavioral state. Observing the behavioral events performed by individuals during an interaction can help define the short-term reactions elicited by the boat presence. I recorded the behavioral events performed by all individuals of focal schools. The frequency of occurrence of all events was compared depending on the presence of vessels, their behavior, and the behavioral state of the focal school. Dolphins tended to perform more side flops while interacting with powerboats, a behavior which may be used as a non-

vocal communication tool. Moreover, the movement of dolphins became more erratic during interactions with all types of vessels. These effects increased when the boats were more intrusive while interacting. This study shows that the impact of interaction with boats can be minimized if the vessels respect the guidelines in place.

Keywords: mammal, New Zealand, marine, wildlife viewing (boat), motorized (boat), boating

Lynch, H. J., W. F. Fagan, and R. Naveen. 2010. Population trends and reproductive success at a frequently visited penguin colony on the western Antarctic Peninsula. *Polar Biology* **33**:493–503.

Petermann Island (65[degree]10[minute]S, 64[degree]10[minute]W), one of the Antarctic Peninsula's most frequently visited locations, is at the epicenter of a rapid shift in which an Adelie penguin dominated fauna is becoming gentoo penguin dominated. Over the course of five seasons, the breeding productivity of Adelie and gentoo penguins breeding at Petermann Island were monitored to identify drivers of this rapid community change. The impact of tourist visitation on breeding success was also investigated. Consistent with larger trends in this region, the Adelie penguin population decreased by 29% and the gentoo penguin population increased by 27% between the 2003/2004 and 2007/2008 seasons. Reproductive success among Adelie penguins ranged from 1.09 to 1.32 creched chicks/nest, which was higher than or comparable to other sites and is an unlikely explanation for the precipitous decline of Adelie penguins at Petermann Island. Whereas gentoo penguin reproductive success was lowest in colonies frequently visited by tourists, Adelie penguin colonies frequently visited by tourists had higher reproductive success than those visited only occasionally. These results are placed in the context of other studies on reproductive success and the impact of tourist visitation on breeding colonies of Adelie and gentoo penguins.

Keywords: bird, Antarctica, polar, hiking

Madsen, J. 1998. Experimental Refuges for Migratory Waterfowl in Danish Wetlands. I. Baseline Assessment of the Disturbance Effects of Recreational Activities. *Journal of Applied Ecology* **35**:386–397.

1. Potential human sources of disturbance, including fishing, sailing, windsurfing and different types of waterfowl hunting, are described and their effects on autumn-staging waterbirds, including mute swan, wigeon and coot, were examined at a coastal wetland in Denmark from 1985 to 1988. 2. Bird and human distributions were superimposed on the distribution of submerged vegetation and water depths to identify the extent of spatial overlap; likewise, seasonal and diurnal temporal overlap in bird abundance, and human activities were defined. Behavioural and distributional reactions of waterbirds to different human activities, in terms of escape distances, disruption of activity patterns and redistribution, were assessed to establish their relative effects. 3. Sailing and windsurfing showed little spatial overlap, and fishing partial spatial overlap with bird distributions; these activities almost ceased before the peak in autumn bird numbers. Hunting showed a high degree of spatial and temporal overlap with bird presence. 4. Birds responded to windsurfing at greatest distances, whereas hunting (especially from mobile punts) caused the longest disruptions to activities of waterfowl. In terms of behaviour and redistribution, wigeon was more affected by shooting than was mute swan or coot. One or two mobile shooting punts reduced wigeon numbers, whereas numbers were unaffected by the presence of up to 4-6 stationary punts; fishing boats had no effect on wigeon abundance. 5. Hunting, especially shooting from mobile punts, was identified as the most disturbing human activity in relation to staging waterfowl in this area. Similar results and conclusions were reached in another comparable study area. The results have implications for refuge designs and zoning of disturbing recreational activities.

Keywords: bird, Denmark, wetland, boating, motorized (boat)

Mainini, B., P. Neuhaus, and P. Ingold. 1993. Behaviour of marmots *marmota marmota* under the influence of different hiking activities. *Biological Conservation* **64**:161–164.

In the region of First near Grindelwald (Swiss alps) alpine marmots *Marmota marmota* reacted differently to various forms of hiking tourism. The smallest reaction was recorded when hikers kept to trails. The reaction increased with cross-country hiking and was even greater when the main burrows of the animals were crossed. The severest reaction was seen in experiments with dogs on a long leash. It can be concluded that the predictability and potential threat (dogs) are decisive factors in the reactions of marmots to different forms of hiking.

Keywords: mammal, Switzerland, hiking

Maljković, A., and I. M. Côté. 2011. Effects of tourism-related provisioning on the trophic signatures and movement patterns of an apex predator, the Caribbean reef shark. *Biological Conservation* **144**:859–865.

Wildlife provisioning, i.e. the provision of bait to generate aggregations of charismatic megafauna as tourist attractions, occurs around the world. This practice is often promoted as an economic incentive to conserve the focal species, yet has stimulated debate based on the potential for risks to human safety and perceptions of behavioural shifts in provisioned populations. We studied a population of Caribbean reef sharks (*Carcharhinus perezii*) in the Bahamas that has been subject to regular provisioning for >20 years. We used a combination of focal observations of sharks during feeding events, remote acoustic telemetry and stable isotope analysis of shark muscle tissue to determine the impacts of provisioning on the trophic signatures and ranging behaviour of sharks in this population. A small number of large sharks monopolised more than 50% of the bait on offer. These 'fed' individuals showed significant ^{15}N enrichment in their tissues compared to conspecifics of the same size that failed to obtain bait at the feeding site, and un-provisioned sharks from a control site. Despite the disparity in trophic signatures, fed, unfed and control sharks exhibited similar degrees of residency at their respective home receiver sites, and travelled similar daily minimum distances. Thus, despite long-term provisioning of this Caribbean reef shark population, there is no evidence for shifts in the behaviours considered which might affect the ecological role of these sharks. However, further research is required to examine potential indirect effects of shark provisioning on sympatric fauna and habitat before this activity can be placed within a sustainable marine conservation framework.

Keywords: fish, Bahamas, marine, wildlife feeding

Mallord, J. W., P. M. Dolman, A. F. Brown, and W. J. Sutherland. 2007. Linking recreational disturbance to population size in a ground-nesting passerine. *Journal of Applied Ecology* **44**:185–195.

* 1 There is often a perceived conflict between recreational access and wildlife conservation. Although many studies have investigated the potential effects on birds, this is the first study to demonstrate an impact of recreational disturbance on population size. * 2 We studied the impact of disturbance on a woodlark *Lullula arborea* population on 16 heathland sites in southern England. These sites all had historical records of breeding woodlarks and together encompassed a range of visitor-access levels. * 3 A logistic regression model of patch use was used to quantify the area of habitat suitable for woodlarks. Woodlarks favoured patches with

substantial proportions of bare ground and short vegetation. Across heaths, woodlark density (per hectare of suitable habitat) was lower on sites with higher levels of disturbance. Within heaths with recreational access, the probability of suitable habitat being colonized was lower in those areas with greater disturbance and was reduced to below 50% at around eight disturbance events per hour. There was no relationship between disturbance and daily nest survival rates. Birds on heaths with higher levels of disturbance fledged more chicks (per pair) because of a strong density-dependent increase in reproductive output. * 4A model is presented that predicts the consequences for the woodlark population of a range of access scenarios. The impact on the population depends on both the numbers of people and their spatial distribution. Under current access arrangements, a doubling of visitor numbers has little effect, while the same number of people distributed evenly across all sites leads to a major negative impact on the population. Density-dependent breeding success partially balances the negative effects of disturbance; however, we calculated that there is currently a 17% reduction in productivity compared with that predicted in the absence of disturbance. * 5Synthesis and applications. Many previous studies have stressed the negative effects of recreational disturbance on birds' behaviour, distribution and breeding success. However, from a conservation viewpoint, the impact at the population level is of paramount importance. Modelling the population-scale consequences of alternative access scenarios will help policymakers develop appropriate mitigation measures.

Keywords: bird, United Kingdom, grassland, scrub/shrub, biking, dog-walking, equestrian, hiking, motorized (land)

Malo, J., P. Acebes, and J. Traba. 2011. Measuring ungulate tolerance to human with flight distance: a reliable visitor management tool? *Biodiversity and Conservation* **20**:3477–3488.

Tourist-induced behavioural changes in large vertebrates are of concern for protected area management as they trigger a trade-off: large vertebrates attract visitors, but induced behavioral changes can reduce animal fitness and cause animals to avoid tourist-frequented zones. Behavioural response of animals to tourists is often studied to ensure informed management decision-making, a task frequently supported by flight distance analysis. In this context, guanaco (*Lama guanicoe*) response to tourists was studied in a protected area using two complementary methods: flight distance and sighting frequency analyses. Flight response analyses show that guanacos develop a considerable tolerance to vehicles and pedestrians in tourist areas, a reaction that extends approximately 500 m around visited areas. Such analyses thus point to (i) few areas being underused as a consequence of human presence and (ii) a low risk of tame animals being poached outside the park, all potentially leading to the conclusion that tourist visits are sustainable. However, guanaco sighting frequencies during 107 fieldwork days along 3 years show a significant reduction in sightings on days with higher Park visitor numbers. Moreover we present a formal procedure for the definition of a threshold for this to happen (247 visitors/day in our case). This suggests the potential risk of negative effects on guanaco population and a lower probability of guanaco sightings if Park visitor numbers rise beyond current figures. Results allow to conclude that assessment of human disturbance to flagship species in protected areas requires further methods in addition to flight distance.

Keywords: mammal, Argentina, scrub/shrub, motorized (land), hiking

Mann, S. L., R. J. Steidl, and V. M. Dalton. 2002. Effects of Cave Tours on Breeding *Myotis velifer*. *The Journal of Wildlife Management* **66**:618–624.

Human activity in caves can affect bats adversely, especially bats that assemble in maternity colonies where appropriate roosts are restricted to areas with a narrow range of microclimates necessary to raise young. We assessed behavioral responses of a maternity colony of about 1,000 cave myotis (*Myotis velifer*) to experimental cave tours by manipulating 3 factors: size of tour groups, whether tour groups talked, and a combination of light intensity and color used to illuminate trails. We also considered the effects of distances between bat roosts and the tour group as well as season. We measured 4 behavioral responses of bats: number of takeoffs, number of landings, activity level, and vocalization intensity. Light intensity affected bat behavior most; all bat responses were highest in trials with high-intensity white light and lowest in trials with no light. When tour groups talked, takeoffs, landings, and activity level increased. Size of tour groups and treatment interactions did not affect bat behaviors. When bats roosted near the tour route, takeoffs and activity level increased. In addition, all behavioral responses increased as the maternity season progressed. Designing cave tours to minimize short-term effects on bats will require careful consideration of cave lighting and tour frequency, route location, and noise levels.

Keywords: mammal, United States, cave, hiking

Maréchal, L., S. Semple, B. Majolo, M. Qarro, M. Heistermann, and A. MacLarnon. 2011. Impacts of tourism on anxiety and physiological stress levels in wild male Barbary macaques. *Biological Conservation* **144**:2188–2193.

Wildlife tourism is a burgeoning global industry with the potential to make a significant contribution to the conservation of endangered species. However, a number of studies have provided evidence that tourists' presence and behaviour may impact negatively on the animals involved, with potentially harmful consequences for their health, reproduction and population viability. Here, we investigate impacts of tourism on wild male Barbary macaques (*Macaca sylvanus*) in Morocco, quantifying a behavioural index of animals' anxiety (self-scratching) and a measure of their physiological stress levels (faecal glucocorticoid concentrations – FGCs). Four measures of tourist presence, number or proximity were explored: maximum number, percentage of time present, mean number while present, and closest proximity to the macaques. In addition, rates of three types of interactions between tourists and macaques – neutral (e.g. photographing), feeding and aggressive – were quantified. Males' rates of self-scratching were positively related to the mean number of tourists present and to rates of all three human-macaque interactions, but were unrelated to the other three measures of tourist pressure. FGCs were positively related to rates of aggressive interactions between humans and macaques, but unrelated to any of the other six measures of tourist pressure. These findings suggest that while tourist presence and interactions (even apparently innocuous ones) with the macaques elevate the study animals' anxiety levels, only aggressive interactions are sufficient to elicit a detectable increase in our measure of physiological stress. These results can be used to inform management of tourism both at this site, and at other locations where tourists view and can interact with wild primates.

Keywords: mammal, Morocco, forest, wildlife viewing (land)

Markovchick-Nicholls, L., H. M. Regan, D. H. Deutschman, A. Widyanata, B. Martin, L. Noreke, and T. Ann Hunt. 2008. Relationships between human disturbance and wildlife land use in urban habitat fragments. *Conservation Biology* **22**:99–109.

Abstract: Habitat remnants in urbanized areas typically conserve biodiversity and serve the recreation and urban open-space needs of human populations. Nevertheless, these goals can be in conflict if human activity

negatively affects wildlife. Hence, when considering habitat remnants as conservation refuges it is crucial to understand how human activities and land uses affect wildlife use of those and adjacent areas. We used tracking data (animal tracks and den or bed sites) on 10 animal species and information on human activity and environmental factors associated with anthropogenic disturbance in 12 habitat fragments across San Diego County, California, to examine the relationships among habitat fragment characteristics, human activity, and wildlife presence. There were no significant correlations of species presence and abundance with percent plant cover for all species or with different land-use intensities for all species, except the opossum (*Didelphis virginiana*), which preferred areas with intensive development. Woodrats (*Neotoma* spp.) and cougars (*Puma concolor*) were associated significantly and positively and significantly and negatively, respectively, with the presence and prominence of utilities. Woodrats were also negatively associated with the presence of horses. Raccoons (*Procyon lotor*) and coyotes (*Canis latrans*) were associated significantly and negatively and significantly and positively, respectively, with plant bulk and permanence. Cougars and gray foxes (*Urocyon cinereoargenteus*) were negatively associated with the presence of roads. Roadrunners (*Geococcyx californianus*) were positively associated with litter. The only species that had no significant correlations with any of the environmental variables were black-tailed jackrabbits (*Lepus californicus*) and mule deer (*Odocoileus hemionus*). Bobcat tracks were observed more often than gray foxes in the study area and bobcats correlated significantly only with water availability, contrasting with results from other studies. Our results appear to indicate that maintenance of habitat fragments in urban areas is of conservation benefit to some animal species, despite human activity and disturbance, as long as the fragments are large.

Keywords: bird, mammal, United States, scrub/shrub, urban, biking, dequestrian

Martin, J., L. de Neve, J. Antonio, V. Polo, and M. Soler. 2004. Factors affecting the escape behaviour of juvenile chinstrap penguins, *Pygoscelis antarctica*, in response to human disturbance. *Polar Biology* **27**:775–781.

Human disturbance can be considered to have similar effects as predation risk for animals. Thus, when disturbed, animal responses are likely to follow the same economic principles used by prey when encountering predators. We simulated predator attacks with different characteristics and in different situations to study the factors that determine the escape response of 1-year-old chinstrap penguins. The results indicate that 1-year-old penguins adjusted their escape behaviour according to the level of risk posed by the researcher acting as a potential predator. When 1-year-old penguins were close to a breeding subcolony, they started to escape later, and fled shorter distances, at lower speeds, and not fleeing directly into the subcolony. This contrasts with their fleeing behaviour far from subcolonies, when penguins fled sooner, for longer, and faster, and in a direction that maximized the distance between themselves and the experimenter, by fleeing directly away from the experimenter. This might suggest the existence of a trade-off between fleeing from the predator and avoiding entering the subcolony where 1-year-old penguins will receive aggressive responses from breeding adults. The type of approach was not important in deciding when to flee. However, penguins did escape for longer distances and faster when approached directly, showing that penguins were able to assess risk level based on predator behaviour. Our findings may have implications for management of penguin colonies visited by tourists. The delimitation of buffer areas and advice on how tourists should behave when approaching penguins might arise from studies of the factors that affect risk assessment of penguins.

Keywords: bird, Antarctica, polar, hiking

Martin, J. G. A., and D. Réale. 2008. Animal temperament and human disturbance: Implications for the response of wildlife to tourism. *Behavioural Processes* 77:66–72.

Studies on the response of wildlife to human disturbance generally focus on demographic changes or on physiological and behavioural modifications directly related to stress response. Yet fewer studies have explored whether the distribution of individual animals in response to human disturbance is influenced by temperament. Temperament represents the consistency of responses of individuals in reaction to novel or challenging situations. Individuals are thus assumed to express highly consistent behaviour-hormonal response under specific stress conditions. In this study, we investigate the relations between exploration, grooming–scanning continuum, emotionality, and docility of individual Eastern chipmunks (*Tamias striatus*) and location of their burrow respective to frequentation by humans. We then assess the relationship between cortisol accumulated in the hair and both temperament and frequentation by humans. Explorative or docile chipmunks were more common in frequented areas. Hair cortisol increased with docility, but was not related to human frequentation. These results indicate that temperament may cause animals to distribute themselves in a non-random way in response to human disturbance. Integrating temperament into studies of the stress response of wildlife to humans could therefore help us understand the impact of tourism on wildlife.

Keywords: mammal, Canada, forest, hiking

Martinez, E., M. B. Orams, M. D. M. Pawley, and K. A. Stockin. 2012. The use of auditory stimulants during swim encounters with Hector's dolphins (*Cephalorhynchus hectori hectori*) in Akaroa Harbour, New Zealand. *Marine Mammal Science* 28:E295–E315.

The coastal distribution of Hector's dolphins and their attraction to vessels make them easily accessible to commercial tour operations. For over 25 yr, tour operators have been undertaking view and swim-with-dolphin trips in Akaroa Harbour, New Zealand. Since 2003, auditory stimulants, in particular stones, have been provided during such swim encounters. The potential effects associated with such stimulants have not, until now, been examined. Here, we investigate the effects of stones and other human-induced noise on Hector's dolphin behavior. The use of stones significantly affected how dolphins interacted with swimmers. Specifically, swimmers who used stones had a greater probability of close approaches by dolphins than those who sang or simply floated on the surface of the water. The number of close and sustained approaches was also significantly higher for swimmers using stones. Dolphins were more interactive with active swimmers, approaching closer and engaging for longer than with nonactive swimmers. Dolphins socializing had a tendency to be engaged longer with swimmers. The use of stones as an auditory stimulant to sustain or enhance interactions with dolphins by artificial means may not be in the best interest of an endangered species, which already faces a range of challenges due to human activity.

Keywords: mammal, New Zealand, marine, swimming/diving

McClung, M. R., P. J. Seddon, M. Massaro, and A. N. Setiawan. 2004. Nature-based tourism impacts on yellow-eyed penguins *Megadyptes antipodes*: does unregulated visitor access affect fledging weight and juvenile survival? *Biological Conservation* 119:279–285.

The Otago Peninsula, South Island, New Zealand offers tourists opportunities for unregulated access to breeding sites of the yellow-eyed penguin (*Megadyptes antipodes*). The presence of people on beaches delays post-foraging landing by penguins, which in turn may affect the amount of food delivered by parents to their

chicks, with consequences for chick growth and fledging mass. This study explored the relationship between human disturbance and yellow-eyed penguin chick fledging weight and survival by comparing five yellow-eyed penguin breeding areas with different levels of visitor frequency. We investigated whether chick fledging weights vary between breeding areas, and whether fledging weight is a predictor of juvenile survival. In 2002, chicks at Sandfly Bay, an area with high numbers of tourists, had significantly lower fledging weights than chicks at Highcliff, an area with no tourist visitors. An analysis of sightings of 2125 yellow-eyed penguin chicks banded between 1981 and 2000 indicated probability of survival was positively associated with mass at fledging. Thus lower fledging weights may have long-term population consequences. Fledging weight is influenced by many factors, however the results suggest the possibility of an effect of tourist numbers on chick fledging weight. This is noteworthy, especially in light of the rapid rate at which wildlife tourism is increasing in coastal areas of southern New Zealand.

Keywords: bird, New Zealand, beach, shoreline, beach use, hiking

McGrann, M. C., G. R. Wright, R. J. Dial, and A. M. McGrann. 2006. Off-highway vehicle impact on the flat-tailed horned lizard, *phrynosoma mcallii*, in the colorado desert of southern california. *California Fish and Game* **92**:67–80.

A randomly selected paired plot design, with dichotomous levels (high impact vs. low impact) of off-highway vehicle activity, was used to measure the effect of this activity on *Phrynosoma mcallii* (flat-tailed horned lizard). We measured lizard density, lizard mass, and food sources (ant mounds) on 4-ha square paired plots that were separated by 300 m. We selected paired plots from two study areas separated by 25 km in Imperial County, California. Low impact plots in the first study area contained greater lizard densities and mean lizard mass with suggestive statistical significance. High impact plots in the second study area contained greater lizard densities, but lizard mass remained greater on low impact plots. When analyzing the combined data from both study areas, only mean lizard mass was greater on low impact plots. For the first, second, and combined study areas, low impact plots contained greater ant mound densities (primary food source). We observed qualitative difference between the two study areas (e.g. recreational vs. non-recreational off-highway vehicle activity). Both recreational and non-recreational off-highway vehicle activity may have negatively impacted the lizard; we recommend increasing protection.

Keywords: reptile, United States, desert, scrub/shrub, motorized (land)

McMillan, M. A., J. C. Nekola, and D. W. Larson. 2003. Effects of rock climbing on the land snail community of the Niagara escarpment in southern Ontario, Canada. *Conservation Biology* **17**:616–621.

The cliffs of the Niagara Escarpment provide habitat for extremely diverse communities of land snails that may be at risk as a result of recreational rock climbing. We examined the effects of rock climbing on the density, richness, diversity, and community composition of snails on the Niagara Escarpment in southern Ontario, Canada. We sampled from randomly selected climbed and unclimbed sections of cliffs on the plateau (cliff edge), cliff face, and talus (cliff base). Snail density, richness, and diversity were lower along climbing routes than in unclimbed areas, and community composition differed between climbed and unclimbed samples. These results suggest that rock climbing has significant negative effects on all aspects of the snail community on cliffs; therefore, we recommend the inclusion of gastropods in conservation plans for protected areas containing cliffs.

Keywords: invertebrate, Canada, forest, rockclimbing

Milazzo, M. 2011. Evaluation of a behavioural response of Mediterranean coastal fishes to novel recreational feeding situation. *Environmental Biology of Fishes* **91**:127–132.

Fish may learn to associate food with human presence through recreational hand-feeding, a popular tourist activity. The conditional learning-e. g. when an organism learns by continuous exposure to one stimulus-of different coastal fish species exposed to novel feeding situations was evaluated. The latencies of learning response to the initiation of supplementary feeding were rapid and species-specific. However differences in the learning response between different fishes decreased over time, demonstrating that associating with others might incur costs especially for small-sized species, likely due to increased competition for food. Nevertheless some other fish species did not acquire any specific human oriented behavior, being naturally timid or avoiding humans.

Keywords: fish, Italy, marine, wildlife feeding

Milazzo, M., I. Anastasi, and T. J. Willis. 2006. Recreational fish feeding affects coastal fish behavior and increases frequency of predation on damselfish *Chromis chromis* nests. *Marine Ecology Progress Series* **310**:165–172.

Wildlife feeding has become an integral part of the range of activities offered to protected area visitors. In marine protected areas (MPAs), fish feeding may cause changes in the behavior, and thus the density and distribution, of coastal fish species. We evaluated spatial variability in human-positive fish behavior around the Ustica Island MPA (Italy) and the potential indirect effects of behavioral change on other species. Two mensurative experiments demonstrated that ca. 1/3 of the species present in fish-feeding areas exhibited human-positive behavior, losing instinctive fear in the presence of humans and encircling people in the water even when food was not provided. A manipulative experiment demonstrated that this behavioral response was learned rapidly. Damselfishes were negatively affected by the unnatural aggregation of a labrid species, as these aggregations frequently attacked and destroyed the benthic nests of the damselfish. Thus, fish feeding can have both direct and indirect effects. Therefore the MPA management goals need to be explicitly stated on a case-by-case basis. If the aim of a reserve is only to promote awareness of marine life and the benefits of conservation to the public, activities such as fish feeding may be regarded as desirable, since the human-positive behavior brought about by this activity guarantees a visual spectacle for visitors. Fish-feeding locations, however, cannot be regarded as natural and may reduce the effectiveness of a reserve for scientific research.

Keywords: fish, Italy, marine, swimming/diving, wildlife feeding

Miller, J. R., J. A. Wiens, N. T. Hobbs, and D. M. Theobald. 2003. Effects of Human Settlement on Bird Communities in Lowland Riparian Areas of Colorado (USA). *Ecological Applications* **13**:1041–1059.

Riparian areas in western North America have been characterized as centers of avian diversity, yet little is known about the ways that native species in streamside habitats are affected by development nearby. To address this issue, we examined patterns of habitat use by birds during the 1995-1997 breeding seasons at 16 lowland riparian sites representing an urban-to-rural gradient. As development increased, riparian woodlands tended to have fewer native trees and shrubs, less ground and shrub cover, higher tree densities, and greater

canopy closure. Bird species richness also declined as urbanization increased in the surrounding landscape. Canonical correspondence analysis (CCA) revealed that measures of settlement intensity best explained variation in habitat use by riparian birds, although some residual variation was accounted for by differences in woodland understory features. Migrant and low-nesting species were associated with lower-than-average levels of development, whereas resident and cavity-nesting species tended to increase with urbanization. In partial CCA analyses, however, local habitat variables explained twice the variation that measures of settlement did; nearly half of all explained variation could be attributed to local and landscape variables simultaneously. For avian guilds based on migratory, nesting, and foraging behavior, regression analyses showed that the best variables for explaining patterns of habitat use were usually those that reflected levels of urbanization, particularly at broad scales. When the effects of local habitat variation were removed, however, the best variables for explaining residual variation in habitat use tended to describe development at relatively fine scales, especially for species that nested or foraged low for insects or seeds. These species were also the most sensitive to human trail use. Our analyses indicated that bird communities and local habitat conditions in riparian areas were both affected by development in the surrounding landscape. It may be possible to mitigate the negative impacts of human settlement on native birds in streamside woodlands by maintaining or restoring vegetation structure and composition, and by imposing limits on human recreational activity in these habitats.

Keywords: bird, United States, forest, freshwater, biking, hiking, jogging/running

Miller, S. G., R. L. Knight, and C. K. Miller. 1998. Influence of Recreational Trails on Breeding Bird Communities. *Ecological Applications* **8**:162–169.

We investigated the influence of recreational trails on breeding bird communities in forest and mixed-grass prairie ecosystems in Boulder County, Colorado, United States, during 1994 and 1995. Species composition, nest predation, and brood parasitism by Brown-headed Cowbirds (*Molothrus ater*) were examined near and away from existing recreational trails. Bird species composition was altered adjacent to trails in both ecosystems. Generalist species were more abundant near trails, whereas specialist species were less common. Within the grassland ecosystem, birds were less likely to nest near trails. Within both ecosystems, nest predation was greater near trails. In forests, the rate of brood parasitism was not influenced by trails. No brood parasitism was found in the grassland ecosystem. Our results may be useful to natural-lands managers who must implement management policies regarding the spatial arrangement of trails and trail-use restrictions.

Keywords: bird, United States, forest, grassland, biking, dog-walking, equestrian, hiking, jogging/running, wildlife viewing (land)

Moore, M. J. C., and R. A. Seigel. 2006. No place to nest or bask: Effects of human disturbance on the nesting and basking habits of yellow-blotched map turtles (*Graptemys flavimaculata*). *Biological Conservation* **130**:386–393.

Considerable recent attention has focused on how human disturbance alters the behaviour of imperiled taxa. Data on such impacts are common for waterfowl, marine mammals, and some large game animals. However, little is known about how human disturbances affect reptiles, perhaps because most reptiles are secretive and are not commonly seen by the public. We studied the impact of human disturbances on the nesting and basking behaviour of the yellow-blotched map turtle (*Graptemys flavimaculata*) on the Pascagoula River in

southeastern Mississippi, USA. We found that both nesting and basking behaviour of map turtles were altered by human recreational activities. Turtles attempting to nest commonly abandoned their attempts upon the approach of a boat and, prior to nesting, numerous individuals waited several hours near the beach without emerging. Basking turtles frequently dove into the water upon the approach of a boat and some did not return to bask. Anglers in small boats that remained in the vicinity of basking sites caused the most disturbances, whereas personal water crafts (jet skis) caused fewer disturbances. Our data suggest that interruption of nesting activities may have an especially severe impact on the viability of this population through changes in numbers of clutches females are able to lay and altering the microhabitat females select for their nests.

Keywords: reptile, United States, beach, freshwater, shoreline, motorized (boat)

Morrison, M. L., R. J. Young, J. S. Romsos, and R. Golightly. 2011. Restoring Forest Raptors: Influence of Human Disturbance and Forest Condition on Northern Goshawks. *Restoration Ecology* **19**:273–279.

The Northern Goshawk (*Accipiter gentilis*) occurs throughout the Holarctic region in wooded environments. Changes in food supply and breeding habitat, along with human encroachment into otherwise suitable habitat, have negatively impacted the goshawk in some regions. Thus, conservation of the species requires coordinated planning to restore and manage both habitat and human activities in goshawk territories. Using our work in the Sierra Nevada (Lake Tahoe Basin) as a case study, we investigated why territories were abandoned and identified actions needed to reverse conditions negatively impacting goshawks that should lead to more successful goshawk conservation worldwide. We summarized all nesting records available on the goshawk in the Basin, quantified human activity levels within and near frequently and infrequently occupied territories, and described the forest structure and species composition of territories and related these parameters to goshawk territory occupancy. As we hypothesized, reproductive success was higher within frequently occupied territories. Human activity was twice as high within infrequently as compared to frequently occupied territories. There was a greater extent of all types of roads and trails within the infrequently occupied territories. Our findings, along with results from Europe, suggest that goshawk protection has been insufficient in some regions and actions that will reduce anthropogenic disturbance should be initiated, including reducing and re-routing human activity, and reducing the extent of roads and trails within territories. We provide guidance on how to prioritize territories for restoration.

Keywords: bird, United States, forest

Müllner, A., K. Eduard Linsenmair, and M. Wikelski. 2004. Exposure to ecotourism reduces survival and affects stress response in hoatzin chicks (*Opisthocomus hoazin*). *Biological Conservation* **118**:549–558.

Ecotourism helps to protect many habitats, but may also have negative impacts on wildlife. We investigated effects of ecotourists on reproductive success of hoatzins (*Opisthocomus hoazin*) and on hormonal status of their chicks in Amazonian rainforest lakes by comparing birds from undisturbed and from tourist-exposed nests. Hatching success was similar in both groups but chick survival was much lower at tourist-exposed nests than at undisturbed nests. This effect was due to an increased mortality of juveniles prior to fledging whereas small nestlings seemed largely unaffected. Juveniles, but not nestlings, living at tourist-exposed sites had a lower body mass and showed a stronger hormonal response to experimental stress compared to individuals at undisturbed sites. These data suggest that juvenile hoatzins were susceptible to tourist-induced stress which in turn may be responsible for the lower survival. In contrast, adult hoatzins that were incubating had apparently

habituated to tourist presence because their flush distances at tourist-exposed nests were 50% lower than at undisturbed sites. Our findings demonstrate that individuals in different life stages show different susceptibilities to tourism. We suggest that even just watching animals during breeding can threaten their survival, but a proper scientific management of off-limit zones and area-specific guidelines for wildlife observation could reduce harmful effects.

Keywords: bird, Ecuador, forest, freshwater, wildlife viewing (boat)

Naylor, L. M., M. J. Wisdom, and R. G. Anthony. 2009. Behavioral responses of North American elk to recreational activity. *Journal of Wildlife Management* **73**:328–338.

Off-road recreation on public lands in North America has increased dramatically in recent years. Wild ungulates are sensitive to human activities, but the effect of off-road recreation, both motorized and nonmotorized, is poorly understood. We measured responses of elk (*Cervus elaphus*) to recreational disturbance in northeast Oregon, USA, from April to October, 2003 and 2004. We subjected elk to 4 types of recreational disturbance: all-terrain vehicle (ATV) riding, mountain biking, hiking, and horseback riding. Motion sensors inside radiocollars worn by 13 female elk recorded resting, feeding, and travel activities at 5-minute intervals throughout disturbance and control periods. Elk fed and rested during control periods, with little time spent traveling. Travel time increased in response to all 4 disturbances and was highest in mornings. Elk travel time was highest during ATV exposure, followed by exposure to mountain biking, hiking, and horseback riding. Feeding time decreased during ATV exposure and resting decreased when we subjected elk to mountain biking and hiking disturbance in 2003. Our results demonstrated that activities of elk can be substantially affected by off-road recreation. Mitigating these effects may be appropriate where elk are a management priority. Balancing management of species like elk with off-road recreation will become increasingly important as off-road recreational uses continue to increase on public lands in North America.

Keywords: mammal, United States, forest, grassland, motorized (land), biking, hiking, equestrian

Neuhaus, P., and B. Mainini. 1998. Reactions and adjustment of adult and young alpine marmots *Marmota marmota* to intense hiking activities. *Wildlife Biology* **4**:119–123.

In the region of First near Grindelwald in the Swiss Alps, experiments were carried out on the reaction of alpine marmots *Marmota marmota* when confronted with hikers. Marmots in highly frequented areas showed less reaction to hiking activities than marmots in remote areas. In adult marmots, there was no change in reaction during the season. In young animals the reaction shortly after leaving the burrows in early July, was slight and similar in highly frequented and remote areas. In late summer, the intensity of the reaction of young animals increased significantly in animals in both study groups but to a much larger extent in the remote areas. We conclude that the perception of danger has to be learned or is built up during growth and development. At the same time, young animals in highly frequented areas may adjust to the presence of hikers.

Keywords: mammal, Switzerland, hiking

Neumann, W., G. Ericsson, and H. Dettki. 2010. Does off-trail backcountry skiing disturb moose? *European Journal of Wildlife Research* **56**:513–518.

The advancement of recreational activities into wildlife habitat calls for a better knowledge about the effects of human-induced disturbances, particularly in systems where humans dominate wildlife mortality. We exposed nine adult free-ranging female moose repeatedly to off-trail backcountry skiing to study moose behavior and habituation using a controlled field experiment in Northern Sweden. Moose response was short-term, but distinct. Moose moved 33-fold faster during the first hour following disturbance, resulting in almost a doubling of the energetic usage per kilogram body weight. Movement rates increased 3 h following disturbances, came along with enlarged activity ranges at the day of disturbance, and resulted in moose leaving the original area. We found no evidence for habituation. Because of the short-term response, the effect of single skiing disturbance events on the overall energy budget of large-bodied animals in good body condition is likely to be negligible. We recommend off-trail skiers to avoid following wildlife tracks because such disturbances bear risk for more severe consequences on wildlife's energy budget if wildlife resists habituation, if an animal's risk perception is high, or when the frequency of disturbance increases.

Keywords: mammal, Sweden, forest, xc skiing

Osinga, N., S. B. Nussbaum, P. M. Brakefield, and H. A. Udo de Haes. 2012. Response of common seals (*Phoca vitulina*) to human disturbances in the Dollard estuary of the Wadden Sea. *Mammalian Biology - Zeitschrift für Säugetierkunde* 77:281–287.

The Dollard area is a core breeding area of common seals, *Phoca vitulina*, in the Dutch Wadden Sea. Seals mainly use this area in the birth season, and it is at this time that mother and pup pairs are prone to disturbance. Seals in the Dollard lie on sandbanks close to the dyke area which exposes them to various human activities on land and in the coastal waters. The colony of common seals on the sandbanks of the Dollard has increased from 77 individuals in 1993 to 332 in 2010. Observations were made during the pupping and lactation seasons in 2007, 2008, 2009 and 2010. In total, 692 h of observations were made over the last 4 years, and a total of 1329 potential disturbances were recorded. Human activities were more frequent on land than on water or in the air. In total, most disturbances were also recorded as arising from land. Actual disturbances of seals were recorded 344 times; seals were alerted 249 times and seals escaped into the water 95 times. An escape response was observed for 81 of the 1037 (7.8%) recorded land activities, 6 of the 92 (6.5%) recorded water activities, and 8 of the 200 (4%) air activities. These percentages of escape responses did not differ significantly between the land, water and air activities. The construction of a culvert in the dyke in 2001, and the building up of sand ridges along the water flow towards the culvert, provided the seals with an extra place to haul out. Land activities only affected seals resting on these sand ridges which are at a distance of 50–200 m of the dyke. Boats have the potential to disturb seals on all sandbanks of the study area. They affected the highest number of seals per disturbance, with up to 117 animals fleeing into the water. Flying at lower altitudes appeared to cause more disturbances of seals. Therefore, the effect of flying at low altitudes (150–300 m) warrants further investigation. Disturbances which lead to fleeing into the water create the potential risk of separating pups from their mothers. This may contribute to the high incidence of orphaned pups found in the Dollard region. Yearly numbers fluctuated between 13 and 24 orphans representing a substantial proportion of the seals born in this area (with highest pup counts of ca. 100). In addition to separation, disturbances may also impact the condition of pups if they occur repeatedly during suckling. The results of this study demonstrate that disturbance is caused by various human activities to a colony of seals using sandbanks close to the mainland. As these disturbances pose a risk that pups become orphaned or are impacted in terms of their body condition, efforts should be made to minimise the effects of human presence.

Keywords: mammal, The Netherlands, freshwater, marine, biking, equestrian, hiking

Paksuz, S., and B. Özkan. 2012. The protection of the bat community in the Dupnisa Cave System, Turkey, following opening for tourism. *Oryx* **46**:130–136.

The aim of this study was to protect the bat community and roosting sites in the Dupnisa Cave System in the Yıldız (Istranca) Mountains in Thrace, the European part of Turkey, following the opening of the caves to tourism. We investigated the seasonal population dynamics and use of the cave system by bats, carrying out 15 surveys before (2002–2003) and 38 surveys after (2004–2008) the cave system was opened to tourism. We recorded 15 species of bats; the highest numbers recorded in a single survey were 54,600 hibernating and 11,000 breeding/nursing. Different parts of the cave system are used by bats to various degrees according to season. To protect the bats and the cave system the visitor schedule took into consideration the differences in seasonal use of the caves by bats. There was a significant increase in the total number of bats recorded in the cave system after opening for tourism, possibly because the gating of two entrances helped to control visitation. The results of our surveys of this cave system show that gating of entrances and visits by tourists are not necessarily incompatible with the use of caves by bats for both hibernating and nursing. Understanding how the three caves are used seasonally by the bat community, and for what purposes (hibernation vs nursing), was critical for the establishment of an appropriate management plan for tourism.

Keywords: mammal, Turkey, cave, hiking

Papouchis, C. M., F. J. Singer, and W. B. Sloan. 2001. Responses of Desert Bighorn Sheep to Increased Human Recreation. *The Journal of Wildlife Management* **65**:573–582.

Human recreation has been implicated in the decline of several populations of desert bighorn sheep (*Ovis canadensis nelsoni*). Managers are concerned about the impact of increased recreation on desert bighorn sheep in Canyonlands National Park (NP), Utah, USA, where visitation increased 325% from 1979 to 1994. We compared behavioral responses of sheep to recreational activity between a low visitor use area and a high visitor use area during 1993 and 1994 by observing behavioral responses, distances moved, and duration of responses to vehicles, mountain bikers, and humans on foot. Hikers caused the most severe responses in desert bighorn sheep (animals fled in 61% of encounters), followed by vehicles (17% fled) and mountain bikers (6% fled), apparently because hikers were more likely to be in unpredictable locations and often directly approached sheep. We observed considerable individual heterogeneity in responses of bighorn sheep to the greater human use: some animals lived close to the road corridor and were apparently habituated to the human activities, but other animals avoided the road corridor. In the high-use area, we observed 3 radiocollared sheep that lived closer to the road than expected and found evidence of fewer responses to vehicles by females in spring, less response time of all sheep to vehicles in spring, and fewer responses to mountain bikers compared to the low-use area. Overall, there was an avoidance of the road corridor by most other bighorn sheep in the high-use area where all animals, on average, were found 39% farther from roads (490 ± 19 m vs. 354 ± 36 m) than in the low-use area. This avoidance of the road corridor by some animals represented 15% less use of potential suitable habitat in the high-use area over the low-use area. Increased sensitivity to hikers in the high-use area was suggested by a greater responsiveness by males in autumn and greater distance fled by females in spring. Responses of bighorn sheep were greater when human activity approached at the same elevation, when sheep were moving or standing, when female interactions occurred in spring and summer and male interactions occurred in autumn, and when sheep were farther from escape

terrain. We recommend managers confine hikers to designated trails during spring lambing and the autumn rut in desert bighorn sheep habitat.

Keywords: mammal, United States, desert, scrub/shrub, hiking, biking

Parent, C., and P. J. Weatherhead. 2000. Behavioral and Life History Responses of Eastern Massasauga Rattlesnakes (*Sistrurus catenatus catenatus*) to Human Disturbance. *Oecologia* **125**:170–178.

Parks and nature reserves protect important natural habitats but also provide public opportunities for outdoor recreational activities that may have unintended negative effects on wildlife. We examined the response of eastern massasauga rattlesnakes (*Sistrurus catenatus catenatus*) to inadvertent disturbance by humans in Killbear Provincial Park, Ontario, Canada. Radio telemetry of 25 adult snakes over two active seasons revealed that, as disturbance increased, gravid females were less visible to observers, but the visibility of non-gravid females and males did not change. Mean distance moved per day decreased and mean time between moves greater than 10 m increased in gravid females, non-gravid females and males with increasing exposure to human disturbance. However, mark-recapture data revealed no differences in the condition or growth rates of snakes, or in the litter size of gravid females, between individuals captured in disturbed and undisturbed study areas. While it is possible that the behavioral responses we observed are not sufficient to have life history consequences, more detailed information on the exposure of individual snakes to human activity is necessary before the conclusion that disturbance is not detrimental to snakes can be accepted. Similarly, other potential negative effects of human disturbance not investigated here remain to be explored.

Keywords: reptile, Canada, hiking

Patthey, P., S. Wirthner, N. Signorell, and R. Arlettaz. 2008. Impact of outdoor winter sports on the abundance of a key indicator species of alpine ecosystems. *Journal of Applied Ecology* **45**:1704–1711.

* 1 Tourism and leisure activities have increased continuously all over the world during the past decades, exerting a growing pressure upon naturally fragile ecosystems, such as mountainous habitats. Recent studies have established that disturbance by outdoor winter sports (e.g. skiing, snowboarding and snowshoeing) is a source of stress for wildlife. This may in turn affect its abundance, but we still lack quantitative evidence. * 2 We tested the effect of outdoor winter sports (ski lifts and related recreational activities) on the abundance of the alpine black grouse *Tetrao tetrix*, a vulnerable indicator species of the timberline ecosystem, the favoured habitat for outdoor winter sports in the European Alps. * 3 Generalized linear models and a model selection approach were used to rank environmental factors influencing black grouse abundance and to make predictions about population status in the theoretical absence of ski resorts. We modelled the number of displaying cocks along census transects in spring, as a function of habitat characteristics (vegetation structure and typology), ski lift density and hunting pressure at 15 natural sites (none or a very low level of anthropogenic disturbance) and 15 ski resorts in the south-western Swiss Alps. * 4 Ski lift density and habitat typology were the principal determinants of black grouse abundance, whereas hunting pressure had no discernable effect. Ski lifts and related winter sport activities had a strong negative effect on the number of displaying cocks, which may have led to a mean 36% reduction of local abundance in ski lift areas, as determined after controlling for the confounding effect of habitat type. * 5 Synthesis and applications. Conservation action plans for black grouse should aim at reducing the multiple negative effects generated by outdoor winter sports (ski facilities and related winter sport activities). First, vegetation patchiness (i.e. a mosaic of grassy shrubland with scattered trees) should be maintained along ski runs. Secondly, wintering

preserves where human access is banned or strictly limited should be promoted within ski resorts. Spatially explicit human–wildlife conflict maps can be constructed from the present model to allow delineation of those areas likely to become effective protection areas.

Keywords: bird, Switzerland, forest, alpine ski/snowboard

Peters, K. A., and D. L. Otis. 2007. Shorebird roost-site selection at two temporal scales: is human disturbance a factor? *Journal of Applied Ecology* **44**:196–209.

* 1Roost-site selection in shorebirds is governed by ambient factors, including environmental conditions and human disturbance. Determination of the extent to which these factors affect roost use and the associated implications for shorebird habitat protection is important for conservation strategies and informed management of human recreational use of these habitats. Shorebird conservation as a whole is a high priority world-wide because a large proportion of shorebird species is in decline. However, little is understood about the consistency of roost use by different species, what conditions affect species-specific roost-site selection, and at what spatial and temporal scales conditions influence selection. * 2We studied high-tide roost-site selection by eight species of non-breeding shorebirds on a critically important stopover and wintering refuge. We calculated spatial and temporal variability in roost use for each species based on counts and consistency of incidence. We then examined roost-site selection in relation to structural, environmental and human disturbance factors, and how this varied across spatial and temporal scales. * 3Most roosts were used less than 50% of the time, although larger roosts were used more consistently. This varied among species, with red knot *Calidris canutus* tending to concentrate at a few roosts and American oystercatcher *Haematopus palliatus*, dowitcher *Limnodromus griseus* and *Limnodromus scolopaceus* and ruddy turnstone *Arenaria interpres* more diffusely distributed among roosts. * 4At an annual scale, the principal factors affecting shorebird presence at roosts were roost length (size), local region, substrate and aspect. The extent and direction of these effects varied among species. Among years, red knots avoided roosts that had high average boat activity within 1000 m, but disturbance did not appear to be a factor for other species. * 5Daily roost use was influenced primarily by wind speed and the ability of roosts to provide shelter from the wind. Only dowitchers appeared to track daily disturbance, avoiding prospective roosts when boat activity within 100 m was high. * 6Synthesis and applications. Our findings emphasize the need to consider species-specific differences in temporal- and spatial-scale effects of roost-site selection factors, including human disturbance, when employing conservation measures for shorebirds. We suggest that conservation management should aim to provide a wide range of potential roosts (both natural and artificial) that could be used under different wind conditions and that are within reasonable travelling distance of preferred feeding areas. Roost use is often highly variable, and monitoring efforts must take this into account before making inferences about changes in use or selection of roost sites.

Keywords: bird, United States, beach, marine, wetland

Pfeiffer, S., and H.-U. Peter. 2004. Ecological studies toward the management of an Antarctic tourist landing site (Penguin Island, South Shetland Islands). *Polar Record* **40**:345–353.

Increasing tourism in the Antarctic Peninsula region concerns scientists, policy-makers, and tourist companies with its potential negative effects on wildlife. Site-specific ecological studies have been initiated to examine differences in population dynamics and distribution of animals as well as their behavioural and physiological reactions to humans. Penguin Island (southeast of King George Island, South Shetland Islands, Antarctica) is

frequently visited by tourists due to its high species diversity and aesthetic value. In two seasons, the authors conducted a bird census and studied behaviour and heart-rate changes of southern giant petrels and skuas relating to tourist visits on Penguin Island. Management recommendations are given, based on the study results. The protection of southern giant petrels should be increased by having a minimum distance of 50 m for all visitors. The eastern, southern, and western parts of the island should not be visited and should serve as refuge areas. The wildlife experience for tourists can still be enjoyed by concentrating visits to the northern and central part of Penguin Island. Use of a specific path to localise impacts in a prescribed area is recommended.

Keywords: bird, Antarctica, polar, hiking

Phillips, G. E., and A. W. Alldredge. 2000. Reproductive Success of Elk Following Disturbance by Humans during Calving Season. *The Journal of Wildlife Management* **64**:521–530.

Restricting human activity in elk (*Cervus elaphus*) calving areas during calving season can be controversial because of increasing human uses of elk habitat, and little evidence exists to evaluate impacts of these activities on elk populations. We evaluated effects of human-induced disturbance on reproductive success of radiocollared adult female elk using a control-treatment study in central Colorado. Data were collected during 1 pretreatment year and 2 treatment years. Treatment elk were repeatedly approached and displaced by study personnel throughout a 3-4-week period of peak calving during both treatment years, while control elk did not receive treatment. We observed elk on alpine summer ranges in July and August on both areas to estimate the proportion of marked cows maintaining a calf. Calf/cow proportions for the control area remained stable, but those for the treatment area declined each year. Average number of disturbances/elk/year effectively modeled variation in calf/cow proportions, supporting treatment as the cause of declining calf/cow proportions. Average decrease in calf/cow proportion in the treatment group was 0.225. Modeling indicated that estimated annual population growth on both study areas was 7% without treatment application, given that existing human activities cause some unknown level of calving-season disturbance. With an average of 10 disturbances/cow above ambient levels, our model projected no growth. Our results support maintaining disturbance-free areas for elk during parturitional periods.

Keywords: mammal, United States, forest, scrub/shrub, tundra, hiking

Picciulin, M., L. Sebastianutto, A. Codarin, A. Farina, and E. A. Ferrero. 2010. In situ behavioural responses to boat noise exposure of *Gobius cruentatus* (Gmelin, 1789; fam. Gobiidae) and *Chromis chromis* (Linnaeus, 1758; fam. Pomacentridae) living in a Marine Protected Area. *Journal of Experimental Marine Biology and Ecology* **386**:125–132.

The short-term behavioural effects of two types of boat noise were tested on *Gobius cruentatus* and *Chromis chromis*, i.e. one permanently and one temporarily benthic vocal fish species living inside the WWF-Natural Miramare Marine Reserve (Northern Adriatic Sea, Italy). The underwater noises produced by a 26-m tourist ferry and a 5-m fiberglass boat were recorded inside the core zone of the reserve. Each type of boat noise was subsequently played back in situ to 10 animals per species (*C. chromis* males caring their nests or *G. cruentatus* in their shelters). The 1/3 octave spectra of recorded sound pressure levels were compared to the underwater ambient noise level and to sound pressure level measured at the hearing threshold of the two species. The boat noise levels have been calculated in terms of particle acceleration for both field measurements and in situ playback projections and subsequently compared to the available measured values

of particle acceleration at the hearing threshold. The animals were free to move in all directions during the whole experimental session. The behaviour of each fish was videotaped by an underwater camera for a total of 10 min (5 min before and 5 min during the noise playback). No short-term behavioural reaction (aversion) was observed in any of the specimen of the two species during the playback of the recorded noises, therefore suggesting no impact. However a time-budget analysis revealed a significant change in the total time spent in caring their nests (*C. chromis*) or inside their shelters (*G. cruentatus*). This result highlighted how analyzing fish reaction on a short-term might underestimate the effects of noise disturbance and indicated that the overall fish behaviour should be considered to assess noise impact.

Keywords: fish, Italy, marine, motorized (boat)

Pineiro, A., I. Barja, G. Silvan, and J. Carlos Illera. 2012. Effects of tourist pressure and reproduction on physiological stress response in wildcats: management implications for species conservation. *Wildlife Research* **39**:532–539.

Context. Ecotourism and human recreational activities are increasing and can have a significant impact on fauna. The analysis of faecal glucocorticoid concentrations is a non-invasive method of measuring physiological stress responses of wildlife to various factors (i.e. human disturbances). Aims. The aim of the present study was to determine whether increased physiological stress levels in wildcats (*Felis silvestris*) were a response to the level of tourism allowed within different zones in a natural park and/or a response to the seasonal reproductive state of wildcats. Methods. The study was conducted from May 2005 to June 2009 at the Natural Park Montes do Invernadeiro (north-western Spain). The Natural Park is divided into the following three zones according to the level of tourism allowed: restricted public-use, restricted zone and integral reserve. An enzyme immunoassay technique was used to quantify cortisol metabolites and sex hormones from each of 110 fresh wildcat faecal samples collected from walked transects on forest roads within each zone. The number of visitors was recorded as a measure of tourist pressure. Key results. The general linear model indicated that park zone and faecal progesterone levels were the factors that explained the variation in the faecal glucocorticoid metabolite levels. Cortisol metabolite concentrations were higher in some park zones where tourism intensity was higher (restricted public-use zone). Faecal cortisol metabolite concentrations were more elevated during gestation (spring) and during the young dispersal period (autumn). Key conclusions. Therefore, we recommend that some zones of park (integral reserve) continue being maintained free of visitor impact and that visitor numbers be specially controlled during the animals' sensitive periods (gestation) in the zone of restricted public use and in the restricted zone.

Keywords: mammal, Spain, forest, scrub/shrub, hiking, motorized (land)

Preisler, H. K., A. A. Ager, and M. J. Wisdom. 2006. Statistical Methods for Analysing Responses of Wildlife to Human Disturbance. *Journal of Applied Ecology* **43**:164–172.

1. Off-road recreation is increasing rapidly in many areas of the world, and effects on wildlife can be highly detrimental. Consequently, we have developed methods for studying wildlife responses to off-road recreation with the use of new technologies that allow frequent and accurate monitoring of human-wildlife interactions. To illustrate these methods, we studied the response of Rocky Mountain elk *Cervus elaphus* L. to all-terrain vehicles (ATVs), one of the most prominent forms of summer recreation in North America. We studied elk because the species is not only of keen economic and social interest across North America and Europe but also exemplifies species that can be sensitive to human disturbance. 2. The study was part of a controlled landscape

experiment where global positioning system (GPS)-equipped recreationists traversed an established 32-km route inside a 1453-ha elk-proof enclosure. Elk locations before and during the human disturbances were monitored using an automated telemetry system. The unique data set and study objectives led to our development of statistical methods for analysing the response of wildlife to human disturbance. 3. We developed a statistical method, referred to as a probabilistic flight response, which accounted for daily circadian rhythms in movement behaviour of elk, and related the probability of flight to distance to the disturbance and a number of environmental covariates. We also present methods for estimating spatially and temporally explicit movement vectors as a way of detecting and visualizing landscape-level movement patterns. 4. Using these methods, we observed that elk appeared to respond at relatively long distances (> 1000 m) to ATVs, and that the estimated probability of flight appeared to be higher when elk were closer to the ATV routes, even when the distance to an ATV was large. 5. Synthesis and applications. Our study quantifies the response of wildlife to human disturbance at a resolution well beyond previous work, and provides methods to improve our understanding of wildlife-human interactions related to management of wildlife and recreation. These methods may be used for any study involving accurate, frequent monitoring of animals and humans with the use of GPS or similar technologies now commonly available.

Keywords: mammal, United States, forest, grassland, motorized (land)

Randler, C. 2006. Disturbances by dog barking increase vigilance in coots *Fulica atra*. *European Journal of Wildlife Research* **52**:265–270.

Animals frequently interrupt their activity to look up and to scan their surrounding environment for potential predators (vigilance). As vigilance and other activities are often mutually exclusive, such behaviours are at the expense of feeding, sleeping or preening. Authors of many wildlife disturbance studies found that people with free-running dogs provoked the most pronounced disturbances (e.g. greater flushing distances and more birds affected). However, dogs on leash may also negatively affect wild animals, and barking dogs may lead to an increase in vigilance. In this study, I tested this hypothesis in coots (*Fulica atra*) using three different playback procedures: (1) dog barks, (2) conspecific coot alarm calls and (3) chaffinch song. The trials were conducted in spring and autumn 2005 at three study sites in southwestern Germany. During the dog playbacks, vigilance increased significantly from 17 to 28%. This increase in vigilance is comparable to the presence of a natural predator. As expected, vigilance also increased significantly during conspecific coot alarm calls but not during playbacks of the chaffinch song control. Two main findings result from the study: (1) coots respond to acoustic traits of dogs and may be able to acoustically recognise this predator and (2) this increase in vigilance might have implications for conservation, especially when considering buffer zones around sensitive areas.

Keywords: bird, Germany, freshwater, shoreline, dog-walking

Raveh, S., W. F. D. van Dongen, C. Grimm, and P. Ingold. 2012. Cone opsins and response of female chamois (*Rupicapra rupicapra*) to differently coloured raincoats. *European Journal of Wildlife Research* **58**:811–819.

Alpine species are often exposed to intense levels of human recreational activities. Exactly how human disturbances influence the behaviour of these species is still open to much debate. For example, little is known regarding how the colourful clothing often worn by tourists influences the behaviour of animals. Tourists wearing colourful clothing may be more conspicuous to local wildlife and thus cause more disturbances. We therefore investigated this question in female chamois (*Rupicapra rupicapra*) in the Swiss Alps. We firstly

investigated, via a morphological and an immunohistochemical approach, whether chamois are likely to have colour vision and would therefore be more likely to respond to different coloured clothing. We detected evidence of two cone types—short-wavelength-sensitive cones (S-cones, JH 455) and middle-wavelength-sensitive cones (M-cones, JH492) in the chamois retina—suggesting that chamois have dichromatic vision, similar to other ungulates. Secondly, via behavioural assays where a person wearing one of three coloured coats commonly worn by tourists (red, yellow and blue) approached a female chamois, we show that neither the alert and flight initiation distance nor the site of refuge were influenced by the raincoat colour. In addition, behavioural responses of the chamois were neither influenced by animal group size nor the presence of kids nor the time of the experiment. The results suggest that, although chamois possess colour vision, they do not react more strongly towards conspicuous colours worn by hikers. We discuss our results in light of what is already known about chamois biology and suggest implications for future studies.

Keywords: mammal, Switzerland, hiking

Reed, S. E., and A. M. Merenlender. 2008. Quiet, nonconsumptive recreation reduces protected area effectiveness. *Conservation Letters* 1:146–154.

Protected areas around the world were created with the goals of preserving biodiversity and providing nature-based recreation opportunities for millions of people. This dual mandate guides the management of the majority of the world's protected areas, but there is growing evidence that quiet, nonconsumptive recreation may not be compatible with biodiversity protection. We combined noninvasive survey techniques and DNA verification of species identifications to survey for mammalian carnivores in 28 parks and preserves in northern California. Paired comparisons of neighboring protected areas with and without recreation revealed that the presence of dispersed, nonmotorized recreation led to a five-fold decline in the density of native carnivores and a substantial shift in community composition from native to nonnative species. Demand for recreation and nature-based tourism is forecasted to grow dramatically around the world, and our findings suggest a pressing need for new approaches to the designation and management of protected areas.

Keywords: mammal, United States, forest, biking, dog-walking, equestrian, hiking

Reed, S. E., and A. M. Merenlender. 2011. Effects of management of domestic dogs and recreation on carnivores in protected areas in Northern California. *Conservation Biology* 25:504–513.

Abstract: In developed countries dogs (*Canis lupus familiaris*) are permitted to accompany human visitors to many protected areas (e.g., >96% of protected lands in California, U.S.A.), and protected-area management often focuses on regulating dogs due to concerns about predation, competition, or transmission of disease and conflicts with human visitors. In 2004 and 2005, we investigated whether carnivore species richness and abundance were associated with management of domestic dogs and recreational visitation in protected areas in northern California. We surveyed for mammalian carnivores and human visitors in 21 recreation areas in which dogs were allowed offleash or onleash or were excluded, and we compared our observations in the recreation areas with observations in seven reference sites that were not open to the public. Carnivore abundance and species richness did not differ among the three types of recreation areas, but native carnivore species richness was 1.7 times greater ($p < 0.01$) and the relative abundances of native coyotes (*Canis latrans*) and bobcats (*Lynx rufus*) were over four times greater ($p < 0.01$) in the reference sites. Abundances of bobcats and all carnivores declined as the number of visitors increased. The policy on domestic dogs did not appear to affect species richness and abundance of mammalian carnivores. But the number of dogs we observed was

strongly associated with human visitation ($R^2 = 0.54$), so the key factors associated with recreational effects on carnivores appear to be the presence and number of human visitors to protected areas.

Keywords: mammal, United States, forest, grassland, dog-walking, hiking

Reimers, E., S. Eftestøl, and J. E. Colman. 2003. Behavior Responses of Wild Reindeer to Direct Provocation by a Snowmobile or Skier. *The Journal of Wildlife Management* 67:747–754.

To better understand the effect of winter tourism and public recreation on wild mountain reindeer (*Rangifer tarandus tarandus*), we compared reindeer response distances after direct provocations by skiers and snowmobiles during 3 winters in Setesdal-Ryfylke, southern Norway. Reindeer being provoked by a snowmobile discovered the observer at longer distances than reindeer being provoked by a skier (370 [skier] vs. 534 [snowmobile] m; $P = 0.002$), while total flight (756 vs. 570 m; $P = 0.037$) and total distance moved (970 vs. 660 m; $P = 0.008$) by reindeer were shorter for snowmobile than skier provocation. The fright (328 [skier] vs. 328 [snowmobile] m), flight (281 vs. 264 m), and escape (543 vs. 486 m) distances due to skier or snowmobile provocation were not different ($P > 0.05$). For pooled data, fright distances of reindeer were affected by 2 other independent variables. Fright distance was longer when the animals were provoked from below rather than from above ($P = 0.046$), while their escape distances were longer when the animals were lying rather than when grazing prior to being provoked ($P < 0.05$). Based on maximum and minimum distance moved for all provocations pooled, daily estimated energy expenditure of reindeer increased between 31 and 590 kJ, representing 0.2 and 2.9% of their estimated total daily energy expenditure. Overall, provocations by skiers or snowmobiles revealed similar behavioral responses. An estimated maximum rate of 3 daily encounters between reindeer and skiers or snowmobiles during winter vacation and Easter would result in moderate energy costs that should be easily compensated for and thus have no demographic consequences. Increasing snowmobile use will, however, significantly expand the area where humans are in contact with reindeer during winter and spring, a period of negative energy balance for reindeer.

Keywords: mammal, Norway, motorized (land), xc skiing

Reimers, E., F. L. Miller, S. Eftestøl, J. E. Colman, and B. Dahle. 2006. Flight by feral reindeer *Rangifer tarandus tarandus* in response to a directly approaching human on foot or on skis. *Wildlife Biology* 12:403–413.

Increasing outdoor activities by humans could negatively influence reindeer and caribou *Rangifer tarandus* populations. We recorded the behaviour of feral reindeer *R. t. tarandus* when a person directly approached them on foot or on skis in Forolhogna, Norway, during March, July and September-October 1996. The farther away the person was when first sighted, the greater the distance the reindeer group fled. The distance the reindeer moved away in response to the approaching person was greatest in July and least in September-October during autumn rut and shortly after the hunting season closed. In September-October rutting activities affected reindeer behaviour more than the disturbance caused by the directly approaching human. Both the distance at which the reindeer group responded by flight and the distance they moved away decreased with increasing group size. Upon flight, when all escape options were available, reindeer more often escaped uphill and into the wind than along level ground, downhill, down wind or crossways to the wind. All reindeer in a group moved towards the approaching human before taking final flight during 50% of 82 disturbance events, the closest approach was within 43 m in March, 24 m in July, and 13 m in September-October. No reindeer group responded by flight when the approaching human was still > 310 m away in

March, > 351 in July, and > 180 in September-October. In relation to the current level of human activity in the area, our observations indicate no serious negative consequences for the reindeer following disturbance from a directly approaching human, not even shortly after the hunting season

Keywords: mammal, Norway, grassland, hiking, xc skiing

Riffell, S. K., K. J. Gutzwiller, and S. H. Anderson. 1996. Does Repeated Human Intrusion Cause Cumulative Declines in Avian Richness and Abundance? *Ecological Applications* 6:492–505.

Human intrusion, the mere presence of people in the environment, has become a dominant form of disturbance in many landscapes. Some forms of intrusion from recreationists and other groups occur repeatedly and can seriously alter avian reproduction, survival, and habitat use. Accordingly, repeated intrusion has the potential to cause impacts that accumulate through time and that are manifested as progressive declines in avian richness and abundance. From 1989 to 1993, we experimentally assessed whether or not temporally cumulative impacts occurred in Wyoming bird communities as a result of repeated intrusion by solitary hikers; the intrusions lasted 1-2 h each week during 10 consecutive weeks of each year's breeding season. We tested a priori hypotheses about declines in overall richness and abundance, relative richness and abundance for sets of common and uncommon species, richness and abundance for six guilds, and separate abundances of four common species. Relative richness and abundance for the set of common species were the only metrics to exhibit significant declines between years during the 5-yr period. The declines in these variables, however, were not cumulative. At a statistical power level of 0.85, minimum detectable differences for many variables were small enough to have allowed easy detection of substantive declines, had any occurred. The yearly effects we detected for some richness and abundance variables may not have led to cumulative declines because individuals displaced one year may have been replaced in subsequent years, and some individuals each year may have habituated to or learned to tolerate the intrusions. For the avian communities and intrusion levels we studied, managers should focus on trying to preclude or ameliorate short-term impacts. Attempts to identify the types and intensities of intrusion that actually cause cumulative declines in richness and abundance should continue. Data about intrusions that do not generate cumulative declines, such as those presented here, are just as important as data about intrusions that do cause cumulative declines; managers need both to define the scope of intrusion disturbances that can lead to cumulative impacts in avian communities. Information about the cumulative effects of intrusion should be used by conservation biologists, wildlife managers, and land-use planners to decide whether or how to control intrusion.

Keywords: bird, United States, forest, grassland, hiking

Rode, K. D., S. D. Farley, J. Fortin, and C. T. Robbins. 2007. Nutritional Consequences of Experimentally Introduced Tourism in Brown Bears. *Journal of Wildlife Management* 71:929–939.

Although numerous studies have documented behavioral effects of nature-based tourism on wildlife populations, few studies have determined whether behavioral changes translate to effects on individual condition and population health. This issue is currently a concern for wildlife managers in Alaska, USA, and Canada where bear viewing is a rapidly growing industry expanding into previously undisturbed bear habitats. Rather than record observations at long established tourism sites, we experimentally introduced bear viewing into 2 relatively undisturbed brown bear (*Ursus arctos*) populations in south-central Alaska. We examined the nutritional consequences of behavioral changes induced by the presence and activity of bear viewers for bears

feeding on early summer vegetation and late-summer salmon (*Oncorhynchus kisutch* and *O. nerka*). We used Global Positioning System collars, monitored food resource availability, and quantified individual resource use and condition for a year prior to and during the introduction of bear viewing. Though bear viewing altered spatiotemporal resource use in all treatments, total resource use declined only when we exposed bears to 24-hour daily human activity. Energy expenditure, indexed as daily travel distances, was significantly higher when bears responded by altering spatial rather than temporal resource use. However, body weight and composition were unaffected by all treatments as bears shifted their foraging to other locations or times. Managers can minimize nutritional impacts of bear-viewing programs by avoiding spatial displacement and providing predictable time periods when bears can access food resources free of human activity. Bears in this study exhibited a high degree of behavioral plasticity, which may be an important factor in identifying flagship species for sustainable ecotourism programs.

Keywords: mammal, United States, forest, freshwater, shoreline, wetland, wildlife viewing (land)

Rode, K. D., S. D. Farley, and C. T. Robbins. 2006a. Sexual dimorphism, reproductive strategy, and human activities determine resource use by brown bears. *Ecology* **87**:2636–2646.

Despite significant sexual dimorphism and differing reproductive strategies in carnivores, sexual segregation is rarely studied and is often overlooked in the management of wild populations. Potential nutritional constraints imposed by sexual dimorphism and differing reproductive strategies between the sexes have important implications, particularly when combined with differential effects of human activities on sex and age classes. We examined the effects of sexual dimorphism, reproductive strategies, and human activities (bear-viewing and hunting) on resource use by different sex and age classes of brown bears (*Ursus arctos*). Sexual segregation of habitat use and effects of experimental bear-viewing were quantified at a single site in south-central Alaska, USA, by capturing, collaring, and observing brown bears at a salt marsh and salmon stream. Effects of salmon capture rate, availability of alternative salmon runs, harvest pressure, and numbers of annual visitors on sex and age class use were examined from data collected or previously published from 13 other sites. Bear-viewing sites on salmon streams where salmon capture rates were low (<4 salmon/hour) resulted in low use by adult males (<10% of all bears), except for sites with falls. However, maximum male use of viewing areas also depended on the availability of alternative salmon streams and harvest pressure. Use of habitats by females with dependent young was significantly related to the prevalence of adult males at the site. Thus, both sexual dimorphism and differing reproductive strategies led to sexual segregation in habitat use by bears. As a result of infanticide, females with young appear to prioritize avoidance of male bears over avoidance of humans when choosing habitats, in contrast to responses documented in herbivores. Because carnivores often exhibit both sexual dimorphism and infanticide, selection for sexual segregation is likely to be high. In these cases, the nutritional demands of large adult males, balanced with responses to human activity, drive dynamic temporal and spatial distributions of individuals in the population.

Keywords: mammal, United States, freshwater, shoreline, wetland, wildlife viewing (land)

Rode, K. D., S. D. Farley, and C. T. Robbins. 2006b. Behavioral responses of brown bears mediate nutritional effects of experimentally introduced tourism. *Biological Conservation* **133**:70–80.

To develop a conceptual understanding of the interaction between tourists and bears, this study examined the responses of brown bears (*Ursus arctos*) to experimentally introduced tourism at Douglas River in south-central Alaska within the framework of current predator–prey theory. Factors eliciting displacement and the

nutritional consequences of behavioral changes were measured. GPS collars were deployed to track temporal and spatial resource use and scan and focal observations were used to quantify foraging efficiency, vigilance behavior, and bear use of various food resources. Total food intake was quantified by combining data on food resource use based on GPS locations and foraging efficiency was measured using spotting scopes from long distances. Seasonal food availability and quality were monitored and utilized as co-variables in comparisons between pre-treatment and treatment years. Though the bear population exhibited significant behavioral differences between the presence and absence of humans, changes in behavior generally mediated effects on total food intake. Adult males at a salt marsh viewing area were the only sex/age class exhibiting reduced food intake resulting from a 15% decline in foraging time when viewers were present. Salmon intake did not differ between pre-treatment and treatment years despite a 10% decline in time spent fishing when viewers were present. The tightly controlled experimental bear-viewing introduced in this study allowed bears to evaluate predation risk associated with human activity and optimally respond to minimize costs due to changes in foraging activities.

Keywords: mammal, United States, marine, shoreline, wetland, wildlife viewing (land)

Rodgers, J. A., and S. T. Schwikert. 2002. Buffer-zone distances to protect foraging and loafing waterbirds from disturbance by personal watercraft and outboard-powered boats. *Conservation Biology* **16**:216–224.

Outdoor recreation and ecotourism can have negative effects on wildlife species, so it is important to determine buffer zones within which activities near critical wildlife areas are limited. We exposed 23 species of waterbirds (Pelecaniformes, Ciconiiformes, Falconiformes, Charadriiformes) to the direct approach of a personal watercraft (PWC) and an outboard-powered boat to determine their flush distances. We used 11 sites with a mixture of low, moderate, and high amounts of human activity along the east and west coasts of Florida during September–November 1998 and April–June 1999. We detected considerable variation in flush distances among individuals within the same species and among species in response to both types of vessels. Average flush distances for the PWC ranged from 19.5 m (Least Tern [*Sterna antillarum*]) to 49.5 m (Osprey [*Pandion haliaetus*]), whereas average flush distances for the outboard-powered boat ranged from 23.4 m (Forster's Tern [*S. forsteri*]) to 57.9 m (Osprey). Larger species generally exhibited greater average flush distances for both types of watercraft. A comparison of the flush distances elicited by each watercraft indicated that only the Great Blue Heron (*Ardea herodias*) exhibited significantly larger flush distances (t test, $p < 0.01$) in response to the approach of the PWC than in response to the outboard, whereas four species (Anhinga [*Anhinga anhinga*], Little Blue Heron [*Egretta caerulea*], Willet [*Catoptrophorus semipalmatus*], and Osprey) exhibited significantly larger flush distances (t test, $p < 0.05$) in response to the approach of the outboard-powered boat than in response to the PWC. Eleven species (68.8%) showed no significant difference (t test, $p > 0.05$) in their flush distances in response to the fast-moving PWC and the outboard-powered boat. Our data suggest that a single buffer-zone distance can be developed for both PWC and outboard-powered vessels. Buffer zones of 180 m for wading birds, 140 m for terns and gulls, 100 m for plovers and sandpipers, and 150 m for ospreys would minimize their disturbance at foraging and loafing sites in Florida.

Keywords: bird, United States, shoreline, motorized (boat)

Rodríguez-Prieto, I., and E. Fernández-Juricic. 2005. Effects of direct human disturbance on the endemic Iberian frog *Rana iberica* at individual and population levels. *Biological Conservation* **123**:1–9.

There is widespread concern about the global decline of amphibians, but little is known about whether and how direct human disturbance might affect populations. The goal of this study was to assess the effects of recreational activities on Iberian frogs *Rana iberica*, an endemic and vulnerable species of the Iberian Peninsula, through observation and manipulative approaches. At the population level, we found that frog abundance decreased with the proximity to recreational areas. At the individual level, the behavioral responses of frogs to repeated disturbance events increased the time to resume pre-disturbance activities, but did not affect significantly flight initiation distances. We simulated different levels of human visitation to the stream banks, and found 80% and 100% decrease in stream bank use with a fivefold and a 12-fold increase in direct disturbance rate, respectively. Recreational activities are negatively affecting Iberian frogs through a loss in the spatial and temporal availability of resources. To reduce the level of local disturbance to this species, we recommend setting up buffer areas ≥ 2.5 m from the streams or reducing visitor rates to fewer than 5 visits per hour (either groups or individuals). The role of direct human disturbance should be considered further as a potential factor affecting local amphibian declines.

Keywords: amphibian, Spain, forest, hiking

Rodríguez-Prieto, I., E. Fernández-Juricic, J. Martín, and Y. Regis. 2009. Antipredator behavior in blackbirds: habituation complements risk allocation. *Behavioral Ecology* **20**:371–377.

Several studies showed that animals allow closer approaches (measured through flight initiation distances, FIDs) by potential predators (e.g., humans) in high-predator density areas, which has been explained by habituation effects. We assessed whether this pattern could be produced by not only habituation but also risk allocation by simulating attacks on blackbirds *Turdus merula* by both usual (pedestrians) and novel (radio-controlled vehicle) potential predators in parks with different levels of human visitation. Individual blackbirds from parks with higher pedestrian rates showed lower FID than individuals from parks with lower pedestrian rates, in response to both usual and novel approaches. Blackbirds adjusted their antipredator behavior to the specific level of pedestrian rate encountered every morning and evening in each park, with higher FID in the period with lower pedestrian rate. Similar responses to usual and novel potential predators among parks and daily variation in antipredator behavior support the risk allocation hypothesis and could not be explained by habituation. However, the rate at which FID was reduced in individuals from low-visited parks to high-visited parks was greater for pedestrian attacks than for novel potential predator attacks, suggesting that habituation is also present in our system and complements the effects of risk allocation. Our results have applied implications: the reduction in FID with increasing human visitation in natural areas is usually attributed to habituation; however, we propose that risk allocation can also reduce antipredator behavior effort to survive in habitats with high levels of recreational activities at the expense of potential physiological costs.

Keywords: bird, Spain, urban, hiking

Romero, L. M., and M. Wikelski. 2002. Exposure to tourism reduces stress-induced corticosterone levels in Galápagos marine iguanas. *Biological Conservation* **108**:371–374.

Unstressed and stress-induced plasma corticosterone levels in Galápagos marine iguanas (*Amblyrhynchus cristatus*) were compared in animals from a site heavily exposed to tourism to animals from a site undisturbed by humans. Initial corticosterone levels not only did not differ between the two groups, but they were 50% of levels in iguanas known to be chronically stressed. These data suggest that iguanas in tourist areas are not chronically stressed. Both groups of iguanas exhibited elevated corticosterone levels after 30 min of capture

and restraint, indicating that they can physiologically respond to stressful stimuli. The stress response was lower, however, at the tourist site. This result indicates that iguanas are physiologically affected by tourism, although it is presently unknown whether these changes are ultimately beneficial or harmful.

Keywords: reptile, Ecuador, shoreline, hiking

Rouphael, A. B., and G. J. Inglis. 2001. "Take only photographs and leave only footprints"?: An experimental study of the impacts of underwater photographers on coral reef dive sites. *Biological Conservation* **100**:281–287.

Impacts caused by recreational scuba diving on coral reefs vary widely among different dive locations and individual divers. Linear modelling was used to explore a range of individual and situational risk factors associated with divers who damaged corals in the Great Barrier Reef Marine Park. Recreational divers were followed for 10–15 min, and all contacts with, and damage to corals were recorded. Information on the dive site, diving experience, gender, and use of an underwater camera were recorded. Thirty-two out of 214 divers (15%) damaged or broke corals, mostly by fin kicks (95%). Impacts were most likely to be caused by male divers, in the first 10 min of the dive, at sites with a large abundance of branching corals. Specialist underwater photographers caused more damage on average (1.6 breaks per 10 min) than divers without cameras (0.3 breaks per 10 min). To explore the effects of gender and use of a camera further, we issued single-use underwater cameras to 31 randomly chosen divers and compared their behaviour to a control group. Use of a camera had no influence on the rate or amount of damage caused by these naïve photographers, but male divers were more likely to break corals and caused significantly more damage, on average, (1.4 breaks per 15 min) than female divers (0.3 breaks per 15 min). Variability in the amount of damage caused by divers in our sample reflected the very different underwater behaviours exhibited by specialist and non-specialist photographers, and male and female divers. Greater understanding of the causes of harmful behaviours by these groups will allow better targeting of on-site interpretative and cautionary information and may prove to be a more palatable management strategy than regulation of site use.

Keywords: invertebrate, Australia, marine, swimming/diving

Rouphael, A. B., and G. J. Inglis. 2002. Increased Spatial and Temporal Variability in Coral Damage Caused by Recreational Scuba Diving. *Ecological Applications* **12**:427–440.

The most dramatic changes in natural environments caused by human recreation are often during the initial use of a site, when the most susceptible and fragile species are disturbed. Approaches to managing the effects of recreational activities often assume that site impacts accumulate under sustained patterns of use and that the rate of accumulation is predictably related to the amount of initial use that individual sites receive. We investigated the patterns of impact caused by the experimental opening of two new scuba diving sites in the Great Barrier Reef Marine Park, Queensland, Australia. Changes in the abundance and condition of corals at the dive sites and two undived (control) sites were monitored for 5 mo before the sites were opened and for a further 13 mo after regular dive visits began. Sampling was stratified at increasing distances (0, 40, and 80 m) away from the point of entry to each site to determine spatial patterns of impact. Despite regular use of the sites by dive charters, impacts occurred as repeated discrete pulses in coral damage that were spatially and temporally heterogeneous. Increases in the density of broken branching corals were typically short-term and occurred asynchronously within a single stratum or dive site. Our results show that repeated use of coral reef dive sites does not necessarily lead to cumulative deterioration in their condition. The heterogeneous patterns

of impact that we detected appear to be associated with variability in diver behavior and to the relatively rapid growth of broken coral branches. To limit damage in these popular environments, management actions that identify and mitigate the causes of damaging behavior are likely to be more pragmatic and efficient than setting numerical limits to site use.

Keywords: invertebrate, Australia, marine, swimming/diving

Sanecki, G. M., K. Green, H. Wood, and D. Lindenmayer. 2006. The implications of snow-based recreation for small mammals in the subnivean space in south-east Australia. *Biological Conservation* **129**:511–518.

The increasing popularity of snow-based recreation activities and the development of ski resorts and associated infrastructure have the potential to affect adversely small mammal fauna that over-winter in the subnivean space. We investigated the effects of human activities on the maintenance of the subnivean space, which is critical to the over-winter survival of small terrestrial mammals in Kosciuszko National Park, south-eastern Australia. The creation of ski pistes, surface ski lifts and over-snow routes involves compression of the snowpack and resulted in small or absent subnivean spaces (average 1.2 cm) and high snow cover densities (generally over 0.5 g cm⁻³ and 0.35 g cm⁻³ respectively). By contrast, the subnivean spaces associated with unmodified snow cover averaged 8–20 cm depending on vegetation type. The density of unmodified snowpack was less than 0.35 g cm⁻³ in June but increased throughout the season to levels comparable to those of compressed snow. When the snowpack was experimentally compressed at 22 sites, destroying the subnivean space, detections of two small mammal species (*Rattus fuscipes* and *Antechinus swainsonii*) significantly ($p < 0.0001$) declined by 75–80%. These species remain active below the snow throughout the winter and depend on the presence of an adequate subnivean space. The removal of vegetation by fire significantly ($p < 0.0001$) reduced the size of the subnivean space regardless of habitat type. Vegetation clearing occurs as part of ground preparation prior to establishing ski runs. Supergrooming, in which surface soil is also disturbed, is likely to have similar (if not more extreme) effects. Nival areas used for snow-based recreation should be managed to minimise negative effects on subnivean fauna, by maintaining natural features associated with subnivean space formation (dense shrubs, boulders and/or microtopography) and confining developments to areas where these features are not present.

Keywords: mammal, Australia, forest, grassland, alpine ski/snowboard, motorized (land), xc skiing

Schierding, M., S. Vahder, L. Dau, and U. Irmeler. 2011. Impacts on biodiversity at Baltic Sea beaches. *Biodiversity and Conservation* **20**:1973–1985.

Sandy and shingle beaches were investigated in 2009 and 2010 along the coast of the Baltic Sea in northern Germany with the purpose of assessing biodiversity gradients from shingle to sandy beaches, from beach to primary dunes, and the impacts of tourism on biodiversity. On nine beach sites, ranging between 100% shingle and 99% sand without shingle, Carabidae, Staphylinidae, and Araneae were studied. Two of the six sandy beaches were open and four were closed to tourists. Additionally, trampling effects from tourists, species richness of plants, and plant cover were investigated on sixteen beaches. According to results, primary dunes showed higher species richness in carabids and spiders, but not in staphylinids. Shingle beaches exhibited lower species richness in Staphylinidae and Araneae, but not in Carabidae. As estimated by the Jackknife II method, shingle beaches were the lowest in total species richness. Trampling intensity ranged from 0 footprints m⁻² day⁻¹ on closed beaches, up to a maximum of 30 footprints m⁻² day⁻¹. On "intensively" used beaches (12 footprints m⁻² day⁻¹, on average), reduction of plant cover was

more pronounced than on "extensively" used beaches (7 footprints m super(-2) day super(-1), on average). Both plant cover and plant species richness were lower on intensively and extensively used beaches than on closed beaches. In arthropods, only staphylinid and spider species richness was significantly lower on open beaches than on closed beaches, but no differences were found in carabids. Referring to our results, trampling effects from tourists have high impact on species richness of sandy beaches, on both intensively and extensively used sites.

Keywords: invertebrate, Germany, beach, beach use

Schlacher, T. A., and L. Thompson. 2012. Beach recreation impacts benthic invertebrates on ocean-exposed sandy shores. *Biological Conservation* **147**:123–132.

Ocean beaches are prime recreational assets and are becoming increasingly urbanised: more beaches today front metropolitan regions, are mechanically cleaned, and are used for recreation by increasing numbers of residents and tourists. This 'urbanisation' of beaches presents complex management and conservation challenges, including the accurate determination of ecological effects caused by human beach use. Here we tested whether spatial variation in recreational beach use translates into ecological changes in the benthic invertebrate assemblages inhabiting the intertidal zone in Eastern Australia. Detected faunal changes were consistent with an interpretation of trampling impacts on the lower part of the beach: here, reductions in key ecological measures were significant in terms of total abundance (–72% to –44% lower than control areas), and species richness (–55% to –5%), resulting in significant shifts in community structure. Conversely, upper-shore assemblages were structurally similar between trampling treatments. Because benthic invertebrates are structurally and functionally important in beach ecosystems (e.g. nutrient cycling, trophic links), human impacts from recreation are likely to propagate beyond the macrobenthos and hence require mitigation. Conservation measures for beaches are challenging in urban settings. However, a practicable approach to systematic conservation planning for urban beaches that recognises the social and political reality of beaches having a prime role as recreational assets while maximising environmental outcomes via spatial zoning and visitor management is not unrealistic.

Keywords: invertebrate, Australia, beach, beach use

Schummer, M. L., and W. R. Eddleman. 2003. Effects of disturbance on activity and energy budgets of migrating waterbirds in south-central Oklahoma. *The Journal of Wildlife Management* **67**:789–795.

We studied effects of disturbance on migrating waterbirds during spring on Cumberland Pool at Tishomingo National Wildlife Refuge, Tishomingo, Oklahoma, USA, 1999 and 2000. We recorded 240 disturbances in 477.5 hr of observation of American coots (*Fulica americana*), American white pelicans (*Pelecanus erythrorhynchos*), black terns (*Chlidonias niger*), blue-winged teal (*Anas discors*), and Franklin's gulls (*Larus pipixcan*). Recreation (n = 208) accounted for 86.7% of all disturbances, natural disturbances (n = 23) accounted for 9.6%, and 3.3% of disturbances (n = 8) were unknown. Boat fishing increased alertness by American white pelicans but did not affect escape behavior. Recreational disturbances caused increases in escape activities and alertness of American coots. However, only boat fishing increased energy expenditure by American coots. Rates of disturbance differed between species and appeared to be correlated to foraging strategies, habitat requirements, and type of disturbance. Therefore, managers of public lands should consider habits and migration chronologies of waterbirds when setting seasonal recreation dates. Modifying recreation policy could reduce rates of disturbance to some waterbirds. Future research should be aimed at constructing

energy budgets and measuring body condition of birds at multiple staging areas during spring to determine whether recreational disturbance ultimately affects reproductive success.

Keywords: bird, United States, freshwater, motorized (boat), fishing (shore), hiking, wildlife viewing (land)

Schurr, M., A. Fuentes, E. Luecke, J. Cortes, and E. Shaw. 2012. Intergroup variation in stable isotope ratios reflects anthropogenic impact on the Barbary macaques (*Macaca sylvanus*) of Gibraltar. *Primates* **53**:31–40.

Interactions with humans impact many aspects of behavior and ecology in nonhuman primates. Because of the complexities of the human–nonhuman primate interface, methods are needed to quantify the effects of anthropogenic interactions, including their intensity and differential impacts between nonhuman primate groups. Stable isotopes can be used to quickly and economically assess intergroup dietary variation, and provide a framework for the development of specific hypotheses about anthropogenic impact. This study uses stable carbon and nitrogen isotope analysis to examine intraspecific variation in diet between five groups of Barbary macaques, *Macaca sylvanus*, in the Upper Rock Nature Reserve, Gibraltar. Analysis of hair from 135 macaques showed significant differences in $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values between a group with minimal tourist contact and groups that were main tourist attractions. Because we observed no overt physiological or substantial behavioral differences between the groups, feeding ecology is the most likely cause of any differences in stable isotope ratios. Haphazard provisioning by tourists and Gibraltarians is a likely source of dietary variation between groups. Stable isotope analysis and observational data facilitate a deeper understanding of the feeding ecology of the Barbary macaques relevant to the role of an anthropogenic ecology for the species.

Keywords: mammal, Spain, scrub/shrub, wildlife feeding, wildlife viewing (land)

Sebastianutto, L., M. Picciulin, M. Costantini, and E. A. Ferrero. 2011. How boat noise affects an ecologically crucial behaviour: the case of territoriality in *Gobius cruentatus* (Gobiidae). *Environmental Biology of Fishes* **92**:207–215.

Gobius cruentatus emit sounds during agonistic interactions. In order to evaluate the effect of boat noise exposure on *G. cruentatus* territorial behaviour, we played a field-recorded diesel engine boat noise during aggressive encounters between an intruder and a resident fish in a laboratory-controlled tank. We tested two factors: role (resident vs. intruder) and condition (noisy vs. silent); the test animals underwent all the treatments in a round-robin design. Agonistic behavior of the residents was modified by boat noise: during the playback residents were more submissive and won less encounters than in the control (silent) condition. We suggest that sound production is an effective tool for territorial defense, since the impairment of acoustic communication due to the recreational boat noise diminished the ability of the resident to maintain its territory.

Keywords: fish, marine, motorized (boat)

Seip, D.R., C. J. Johnson, and G. S. Watts. 2007. Displacement of mountain caribou from winter habitat by snowmobiles. *Journal of Wildlife Management* **71**:1539-1544.

Mountain caribou are an ecotype of woodland caribou (*Rangifer tarandus caribou*) that live in subalpine forests in southeastern British Columbia, Canada, extending into northern Idaho and Washington, USA.

These caribou are listed as Threatened in Canada, Endangered in the United States, and are the subject of recovery planning efforts in both countries. Many areas of mountain caribou winter habitat experience intensive use by recreational snowmobilers. During 4 surveys, we recorded caribou on all 4 census blocks with little or no snowmobile activity (\bar{x} density = 0.41 caribou/km²), but during 3 of 4 years, we observed no caribou on the census block with intensive snowmobile activity. The year we observed caribou on the snowmobile block, most were using areas inaccessible to snowmobiles. We used a Resource Selection Function (RSF) based on radiotelemetry data for the area to compare habitat quality among the different census blocks. The absence of caribou from the intensive snowmobile area during most years could not be explained by differences in habitat quality. The RSF predicted that the intensive snowmobile area could support 53-96 caribou (95% CI). We conclude that intensive snowmobiling has displaced caribou from an area of suitable habitat. We recommend that snowmobile activity be restricted from all or most high-quality mountain caribou habitat as part of the recovery planning process.

Keywords: mammal, Canada, forest, tundra, motorized (land)

Semeniuk, C. A. D., S. Bourgeon, S. L. Smith, and K. D. Rothley. 2009. Hematological differences between stingrays at tourist and non-visited sites suggest physiological costs of wildlife tourism. *Biological Conservation* **142**:1818–1829.

Wildlife tourism alters the environmental conditions in which the focal animal lives, and it is therefore necessary to assess the ability of the animal to adjust to and persist in these novel conditions if the industry is to be sustainable. Here, we report on the physiological responses of southern stingrays (*Dasyatis americana*) which are the focus of intense marine provisioning-tourism in the Cayman Islands. Using stingrays from non-tourist sites about Grand Cayman as a basis for comparison, we show in this natural experiment that tourist-exposed stingrays exhibit hematological changes indicative of physiological costs of wildlife tourism. The novel conditions with which the stingrays must interact include non-natural food, higher injury rates (from boats, conspecifics and predators), and higher parasite loads (from crowding conditions). As a result of this year-round environment, stingrays display sub-optimal health: lower hematocrit, total serum protein concentrations, and oxidative stress (i.e., lower total antioxidant capacity combined with higher total oxidative status). Moreover, they show evidence of attenuation of the defense system: for tourist stingrays only, animals possessing both injuries and high parasite loads also exhibit lowest leukocrit, serum proteins and antioxidant potential, as well as differing proportions of differential leukocytes indicative of suppression (lymphocytes and heterophils) and down-regulation (eosinophils), thus suggesting that the physiological changes of tourist stingrays are in partial response to these stressors. While survival- and reproduction- quantification was not possible in this long-lived marine species, the physiological measures -situated within ecological context, indicate that the long-term health and survival of tourist stingrays have a significant probability of being affected. Consequently, management of the tourism attraction is essential. The indicators chosen in this study reflect general health indices and defense capabilities used across taxa, and represent a tradeoff between ease of collection/analysis and interpretation so that managers can continue the research for monitoring purposes.

Keywords: fish, Cayman Islands, beach, wildlife feeding, wildlife viewing

Semeniuk, C. A. D., and K. D. Rothley. 2008. Costs of group-living for a normally solitary forager: effects of provisioning tourism on southern stingrays *Dasyatis americana*. *Marine Ecology Progress Series* **357**:271–282.

Animals can perceive tourists as predators and will incur fitness costs should their predator-avoidance behaviours result in forgone resource acquisition. Not all wildlife, however, treat tourists as predators; animals can respond positively to tourists, especially when food is used as an attractant. We investigate the costs posed by novel grouping over a tourism-provisioned food resource in a normally solitary forager, the southern stingray *Dasyatis americana*, in Grand Cayman. Specifically, we test the hypotheses that group-living stingrays in a new environment—which includes both the presence of tourists and quickly renewing food patches—will be exposed to increased injuries, ecto-dermal parasites and aggressive interference competition that result from the unusual grouping behaviour. We found that, in comparison to stingrays from non-tourist sites, tourist-fed stingrays are more likely to have lower body condition, be injured by boats and predators, be susceptible to ecto-dermal parasites, and be engaged in intense interference competition (in the form of conspecific bite marks). Stingrays from tourist sites also have significantly higher mean numbers of injuries, parasites, and median bite marks. By exploring alternative hypotheses to explain the pattern of our findings (e.g. natural causes/behaviour), we unequivocally show that the impacts incurred by the stingrays stem from the effects of tourism. These findings suggest that novel grouping poses costs to the stingrays; the tourist site represents a riskier habitat with regards to injury and predation; and there may be long-term fitness consequences. From a management perspective, measures should be taken to alleviate the crowded conditions at tourist sites, in terms of both boat and stingray density.

Keywords: fish, Cayman Islands, marine, wildlife feeding, wildlife viewing (boat)

Semenova, O. V. 2008. Ecology of ground beetles in an industrial city. *Russian Journal of Ecology* **39**:444–450.

Specific ecological features of ground beetles inhabiting city parks and suburban areas were studied in the large industrial city of Nizhnii Tagil (Sverdlovsk oblast). Carabid cenoses of city parks retained considerable species diversity but proved to be strongly dominated by a limited number of species. An analysis of their state before and after recreational impact revealed changes in the species composition of communities, the set of dominant species, the degrees of their dominance, and the ratio between classes of life forms. The results show that the stronger the recreational impact, the more significant the decrease in the species diversity of the carabid community.

Keywords: invertebrate, Russia, forest, grassland, urban

Sheppard, N., K. A. Pitt, and T. A. Schlacher. 2009. Sub-lethal effects of off-road vehicles (ORVs) on surf clams on sandy beaches. *Journal of Experimental Marine Biology and Ecology* **380**:113–118.

Ecological impacts of vehicle traffic are a significant environmental management issue on many sandy shores. Impacts usually focus on lethal effects of vehicles to organisms, but sub-lethal effects which could reduce the fitness of macrofauna populations are equally possible but unknown. Consequently, we measured changes in body condition and burrowing performance of the beach clam *Donax deltooides* subjected to vehicle traffic on sandy shores in eastern Australia. Body mass index of clams on beaches open to traffic was 16% lower, but gonadosomatic index and relative valve thickness were not consistently linked to vehicle access to beaches. By contrast, off-road vehicles significantly impaired the burrowing performance of clams. After experimental exposure to ORV traffic (30 passes) and dislodgement from the sediment, the time taken for clams to re-bury into the sand doubled irrespective of the vehicle weight used. Because burrowing is such a critical function in the behavioural repertoire of sandy beach animals, the traffic-induced changes to organisms' performance

found in this study may increase mortality by causing displacement to less favourable habitats by swash, and by intensifying the risk of predation and desiccation. When assessing the ecological impacts of vehicles on beach fauna, it is thus important to consider both lethal and sub-lethal effects.

Keywords: invertebrate, Australia, beach, motorized (land)

Shively, K. J., A. W. Alldredge, and G. E. Phillips. 2005. Elk reproductive response to removal of calving season disturbance by humans. *Journal of Wildlife Management* **69**:1073–1080.

We evaluated elk (*Cervus elaphus*) reproductive success following removal of human disturbance during calving season, by comparing data from 2 segregated groups of free-ranging elk (control and treatment) from 1 pre-disturbance year, 2 disturbance years, and 2 post-disturbance years. Treatment-group elk were subjected to simulated recreational activity during calving season in disturbance years but not in pre- or post-disturbance years. Control animals experienced only ambient levels of disturbance throughout the study, and their calf/cow proportions (proportion of marked adult female elk maintaining a calf in Jul and Aug) were similar throughout the 5 years. We observed reduced productivity of treatment-group elk compared to controls during disturbance years after adjusting for nontreatment year differences. We hypothesized that productivity would return to, or potentially exceed, pre-disturbance levels following removal of disturbance. Productivity rebounded following release from disturbance, and full recovery was achieved by the second post-disturbance year. However, we did not observe productivity in excess of pre-disturbance years, as might be expected if release from energetic demands of maintaining a calf in 1 year increases probability of maintaining a calf in the following year. Our results are consistent with hypotheses that human-induced disturbance during parturition periods can reduce reproductive success and that removal of disturbance can allow productivity to recover to pre-disturbance levels. Managers of wildlife and wildlife habitat should consider potential impacts of human-induced disturbance on wildlife populations. Wildlife populations, depressed by human-induced disturbance during the neonatal period, may have the ability to rebound if the disturbance is removed.

Keywords: mammal, United States, forest, hiking

Sibbald, A. M., R. J. Hooper, J. E. McLeod, and I. J. Gordon. August. Responses of red deer (*Cervus elaphus*) to regular disturbance by hill walkers. *European Journal of Wildlife Research* **57**:817–825.

Disturbance to wildlife from human recreational activities is increasing as remote areas become accessible to greater numbers of people. We used Global Positioning System tracking collars to monitor the movements of red deer (*Cervus elaphus*) stags (n=8) in a herd whose feeding grounds lie close to a popular walking track in the Highlands of Scotland. The track is used by around 20,000 walkers per year and is busiest in summer and at weekends. In a 2-year study, the locations of collared deer were recorded at 2-h intervals on typically busy days (Sundays: mean number of walkers=204) and quiet days (Wednesdays: mean number of walkers=49) during May and June. The deer were consistently further from the track on Sundays than Wednesdays (371 vs 286 m) and moved greater distances between fixes (365 vs 308 m). The amount of time spent (percentage of total fixes) in the small area of grassland closest to the track was lower on Sundays than Wednesdays (6% vs 13%). Although 97% of walkers use the track during the day (between 0800 and 2000 h), there was no evidence of compensatory use of grassland at night, when the deer moved to higher ground dominated by heather moorland. The results demonstrate that animals which appear to be habituated to regular disturbance

within their home territory may nevertheless alter their behaviour and potentially diet composition, as a result of that disturbance.

Keywords: mammal, United Kingdom, grassland, wetland, hiking

Skagen, S. K., C. P. Melcher, and E. Muths. 2001. The Interplay of Habitat Change, Human Disturbance and Species Interactions in a Waterbird Colony. *American Midland Naturalist* **145**:18–28.

Potential responses to human disturbance at breeding colonies of waterbirds include reproductive failure, population declines and displacement from activity areas. Several additional factors, including species interactions and environmental change, can either mask or intensify the effects of human activity. This study highlights the importance of considering these factors in concert with breeding biology when assessing the impacts of human disturbance on wildlife. We studied the effects of a Wildlife Viewing Area (WVA) at Chatfield State Recreation Area, Colorado, on a nesting colony of great blue herons (*Ardea Herodias*) and double-crested cormorants (*Phalacrocorax Auritus*). We stratified the colony's nest trees into near, middle and far areas relative to distances from the WVA and compared the distribution of nests, nesting and fledging success and breeding chronology among areas 2 y before and 2 y after construction of the WVA. We also evaluated whether adult nest attendance patterns and chick behavior differed relative to distance from the WVA. The number of active heron nests and nest success of herons declined during the study, but evidence that these declines were due solely to human disturbance is equivocal. These changes were most likely due to the interplay of habitat changes (loss of 14 of 31 original nest trees by windfall), acquisition of heron nests by cormorants and human disturbance. We found no evidence that cormorants were adversely affected by the WVA in distribution of nests, nesting and fledging success, breeding chronology, adult nest attendance or chick behaviors. Habitat changes and adverse weather contributed to nesting failures of cormorants.

Keywords: bird, United States, forest, wetland, wildlife viewing (land)

Smith-Castro, J. R., and A. D. Rodewald. 2010. Effects of Recreational Trails on Northern Cardinals (*Cardinalis cardinalis*) in Forested Urban Parks. *Natural Areas Journal* **30**:328–337.

Though typically considered benign, recreational trails have the potential to both alter vegetation and disturb birds in ways that might influence parental nest attendance rates and other behaviors that ultimately can affect reproductive success. We hypothesized that recreational trails negatively impact avian reproductive success either by (1) reducing nest attendance due to direct human disturbance or (2) modifying vegetation characteristics surrounding nests. From April to August of 2006 and 2007, 263 nests of Northern Cardinals (*Cardinalis cardinalis*) were monitored in 14 forested riparian sites containing paved and unpaved recreational trails in central Ohio. Vegetation characteristics were measured around 161 nests and 114 random locations. Trail use was estimated using cameras at seven of 14 sites. Nest attendance was not related to distance to trail, nest height, or trail use. We found little evidence that daily nest survival rates were related to distance to trail, nest attendance, trail use, or site. Rather, daily nest survival was best explained by and positively related to nest height. Though vegetation characteristics in randomly-located plots were unrelated to distance from trail, nests closer to trails were surrounded by more small stems (dbh < 8 cm), less native vegetation, and were placed at greater heights and farther from the foliage edge. Thus, birds may modify nest-site selection in relation to recreational trails.

Keywords: bird, United States, forest

St. Clair, J. J. H., G. E. García-Peña, R. W. Woods, and T. Székely. 2010. Presence of mammalian predators decreases tolerance to human disturbance in a breeding shorebird. *Behavioral Ecology* **21**:1285–1292.

Nonlethal disturbance can impose fitness costs, particularly during sensitive life history stages such as reproduction. Prey animals are thus expected to assess the costs and benefits of expressing antipredator behavior in different circumstances and to respond optimally according to the perceived risk of predation. One prediction of this hypothesis is that the response to nonlethal disturbance should be elevated when the risk of predation is high, although few studies have tested this prediction with respect to the distribution of actual predators in nature. We used landscape-level variation in the distribution of large mammalian predators (feral cats) to investigate antipredator behavior in a small breeding shorebird, the Two-banded Plover *Charadrius falklandicus*. We used 8 sites in the Falkland Islands and Argentina and measured the flushing distances of incubating Two-banded Plovers in response to a controlled human approach to the nest. We found that flushing distances were increased at sites where mammalian predators were present and decreased where exposure to humans was high. These effects were additive, and we interpret them as the effects of generalization and habituation, respectively.

Keywords: bird, Argentina, shoreline, hiking

Stalmaster, M. V., and J. L. Kaiser. 1998. Effects of Recreational Activity on Wintering Bald Eagles. *Wildlife Monographs*:3–46.

We studied how recreational activity affected wintering bald eagles (*Haliaeetus leucocephalus*) on the Skagit River Bald Eagle Natural Area (SRBENA) in northwest Washington in 1985-86, 1986-87, and 1987-88. Winter use of the SRBENA was high for both eagles (peak of 264 birds/day) and recreationists (peak of 115 events/day), and human-eagle interactions were common. Our study assessed how recreationists affected eagle numbers, distribution, activity, and feeding on chum salmon (*Oncorhynchus keta*). The number of eagles in our study area was negatively correlated with the daily number of recreational events ($n = 163$ days, $R = -0.679$, $P < 0.01$), and feeding activity declined exponentially with increased recreational activity ($r = -0.445$, $P < 0.001$). On weekends when recreational use was high, fewer eagles used the river and they fed less than on weekdays; feeding was high following weekend disturbances. Disruption of feeding activity was most pronounced between 0800 and 1100 hours. An empirically-derived model predicted that feeding was reduced 35% in the SRBENA because of recreational use. Based on flushing responses and flushing distances, foot traffic was most disturbing to eagles, fishing boats were intermediate in effect, and eagle-viewing boats were least disturbing ($P < 0.001$). However, boat traffic, especially motorboats, disturbed a greater portion of the eagle population than foot traffic. Boats that were early in the daily sequence of events and in early-morning hours were most disruptive to eagle behavior ($P < 0.01$). Eagles feeding on the ground were less tolerant ($P < 0.001$) of recreationists than eagles perching in trees. Flushing responses were lower and flushing distances were shorter ($P < 0.05$) on weekends than on weekdays. Eagles resumed feeding relatively rapidly after the initial disturbances of the day, but, after 20 recreational events, eagles were slow to resume eating and, after 40 events, feeding was uncommon ($P < 0.05$). Feeding resumed rapidly after disturbance by fishing boats ($P < 0.05$) and slowly after eagle-viewing boats ($P < 0.05$), because fishing boats were earlier in the daily sequence of events. Eagles required nearly 4 hours to resume feeding after disturbance by foot traffic compared to 36 minutes after boat traffic. Experimental boat disturbances ($n = 156$) indicated that eagle numbers were lower on weekends and in afternoons because of recreational activity ($P < 0.01$) subadults were less tolerant of disturbance than adults ($P < 0.05$), and boating was more disturbing on narrow than on wide river channels.

Our evidence indicated that some eagles were displaced to secluded areas during disturbances. Flushing responses declined over the winter season ($P < 0.001$), but flushing distances were unchanged ($P > 0.05$). We recommend prohibiting recreational activity in the SRBENA during the first 5 hours of daylight within 400 m of eagles to minimize disturbance of feeding behavior, restricting foot traffic and the use of motorboats, enhancing chum salmon runs in secluded river reaches, and providing public education to increase support for management actions.

Keywords: bird, United States, forest, freshwater, hiking, boating, motorized (boat)

Stamation, K. A., D. B. Croft, P. D. Shaughnessy, K. A. Waples, and S. V. Briggs. 2010. Behavioral responses of humpback whales (*Megaptera novaeangliae*) to whale-watching vessels on the southeastern coast of Australia. *Marine Mammal Science* **26**:98–122.

This study assessed the short-term responses of humpback whales to whale-watching vessels during their southward migration along the south coast of New South Wales (NSW), Australia. The behavior of pods was recorded from commercial whale-watching vessels during tours and compared to pods observed in the absence of vessels from the shore in the same area. While some individuals showed obvious signs of horizontal avoidance, others approached vessels, initiating interactions. Calf pods were more sensitive to the presence of vessels than non-calf pods. Dive times and the overall percentage of time whales spent submerged were higher in the presence of vessels, but respiration intervals did not differ. Some surface behaviors occurred less often in the presence of vessels. Whales' responses differed according to whether vessels were operating in accordance with regulations or not. Whales were more likely to avoid a vessel moving within the permitted 100 m approach limit than vessels outside the limit. Whales showed some behavioral changes when vessels operated in accordance with whale-watching regulations, compared with whales in the absence of vessels. Pods that showed no obvious horizontal responses to vessels changed their diving and surface activity when compared with pods in the absence of vessels. Because the long-term impacts of effects of vessels are unknown, management of the humpback whale-watching industry should adopt a conservative approach. Improved knowledge of long-term impacts of multiple exposures to vessels is required to inform management of the effects of whale-watching.

Keywords: mammal, Australia, marine, wildlife viewing (boat)

Steckenreuter, A., R. Harcourt, and L. Moeller. 2011. Distance does matter: close approaches by boats impede feeding and resting behaviour of Indo-Pacific bottlenose dolphins. *Wildlife Research* **38**:455–463.

Context. Potential impacts of human disturbance on animal populations can be measured as behavioural responses and may affect the survival and fecundity of animals. In areas where human-wildlife interactions occur, conservation management needs to be in place to secure both a viable tourism industry and the sustainability of the targeted species. Aims. We sought to evaluate whether different approach distances by boat have effects on the behaviour and group cohesion of dolphins that are targeted by Australia's largest dolphin-watching industry. Methods. The effects of different approach distances of boats on the behavioural states of dolphins, group dispersal and direction of movement were investigated in this area by controlled boat experiments conducted between August 2008 and December 2009. Key results. Results showed that there was significantly less feeding when boats approached dolphin groups to a distance of 50 m than when they did to a distance of 150 m, or with controlled approaches. Resting was also observed significantly less when boats approached to a distance of 50 m than when they approached to a distance of 150 m. The dispersal of

dolphin groups was significantly tighter (less dispersed) when boats approached to 50 m than that with 150-m-distance or controlled approaches. Furthermore, the dolphins' direction of movement was less neutral when the experimental boat approaches were carried out at a distance of 50 m than when they were carried out at a distance of 150 m, or with controlled approaches. Similar results were also obtained for dolphin groups including calves. **Conclusions.** On the basis of the results from this study, we recommend that the existing New South Wales regulations, which stipulate that dolphin-watching boats keep a distance of 50 m to groups with adults only and 150 m to groups with calves, are maintained within the Port Stephens-Great Lakes Marine Park (PSGLMP). **Implications.** Management plans whose stated goals include both sustainability of a dolphin-watching industry and longer-term viability of a dolphin population may reconcile conflicting objectives and improve their decision making by using these empirical measures rather than best guesses.

Keywords: mammal, Australia, marine, wildlife viewing (boat)

Steidl, R. J., and R. G. Anthony. 1996. Responses of Bald Eagles to Human Activity During the Summer in Interior Alaska. *Ecological Applications* **6**:482–491.

Along narrow rivers, spatial restriction of human use based on wildlife responses can effectively eliminate the entire river corridor from human use. Therefore, if river use by both wildlife and humans is a goal, an alternative management strategy is necessary. We measured flush response rate and flush distance of breeding and nonbreeding Bald Eagles (*Haliaeetus leucocephalus*) to recreational boating along the Gulkana River in interior Alaska from 1989 to 1992. Eagle responses to our nonmotorized boat were governed by the context within which human-eagle encounters occurred. Flush response rate of nonbreeding eagles decreased as perch height and its distance from the river's edge increased, increased as the season progressed and as eagle group size increased, was lower for juveniles (20%) than other age classes (49–65%), and varied with the existing level of human activity in a geographic location ($P < 0.01$ for all parameters). Flush distance of nonbreeding eagles increased as the distance a disturbance was first visible to a perched eagle increased, as perch height and its distance from the river's edge increased, and as the season progressed. In contrast to flush response, flush distance was strongly associated with age and was greatest for adults, least for juveniles, and intermediate for subadults. Breeding adults were much less likely to flush than nonbreeding adults, and flushed at lesser distances. We recommended that along narrow wilderness rivers, the impacts of human activity on Bald Eagle populations be regulated with temporal, rather than spatial, restrictions.

Keywords: bird, United States, forest, freshwater, tundra, boating, motorized (boat)

Steidl, R. J., and R. G. Anthony. 2000. Experimental Effects of Human Activity on Breeding Bald Eagles. *Ecological Applications* **10**:258–268.

To assess the consequences of increased recreational activity in wilderness areas, we studied the effects of human activity on breeding behavior of Bald Eagles (*Haliaeetus leucocephalus*) in interior Alaska. Activity budgets of breeding eagles changed considerably when humans were camped for 24 h at a distance of 100 m from nests (treatment) compared to when they were camped 500 m from nests (control) ($P = 0.0036$). With humans near nests, adult eagles decreased the time they preened (percentage change from control to treatment = -53%), slept (-56%), maintained nests (-50%), and fed themselves and their nestlings (-30%) and increased the time they brooded nestlings (+14%). Further, overall activity (total number of behaviors performed by adults at nests per day) decreased by 27% with humans near nests, as did the amount of prey adults consumed

(-26%) and fed to nestlings (-29%). In contrast, nest attendance did not change with humans near nests (percentage change = 0.3%, $P = 0.9$); however, the time adults were absent from the nest area (≥ 200 m from nests) increased by 24% with humans near nests ($P = 0.013$). Throughout 24-h treatments, eagle responses to nearby humans diminished, suggesting that eagles habituated to the disturbance. During the last 4 h of treatment, however, adults still vocalized twice as frequently as controls, indicating continued agitation. Human activity near nests caused clear and consistent changes in behaviors of breeding eagles, suggesting that frequent human activities near nests could adversely affect nestling survival, and therefore reproductive success.

Keywords: bird, United States, forest, freshwater, tundra

Steiner, A. J., and S. P. Leatherman. 1981. Recreational impacts on the distribution of ghost crabs *Ocyode quadrata* fab. *Biological Conservation* **20**:111–122.

Studies were conducted at Assateague Island, Maryland-Virginia, to determine the relative number of ghost crabs *Ocyode quadrata* Fab. on beaches subject to different recreational uses. The mean density of crabs per 0.1 ha plots was found to be 10 on an undisturbed beach, 19 on a pedestrian-impacted beach, 1 on a light off-road vehicle (ORV)-and pedestrian-impacted beach, and 0.3 in a heavy ORV-use beach. ORVs could be adversely affecting the crabs directly by crushing or burying them or indirectly by interfering with their reproductive cycle or altering their environment. Vehicular disturbance probably results in fewer crabs or no reproduction at all, with new inhabitants migrating from undisturbed areas. Pedestrians appear to have no harmful effects on ghost crabs; instead the crabs may be capitalising on the food scraps scattered across the beach by bathers.

Keywords: invertebrate, United States, beach, beach use, hiking, motorized (land)

Stensland, E., and P. Berggren. 2007. Behavioural changes in female Indo-Pacific bottlenose dolphins in response to boat-based tourism. *Marine Ecology Progress Series* **332**:225–234.

We investigated the behavioural changes of Indo-Pacific bottlenose dolphins *Tursiops aduncus* in response to boat-based tourism at both group and individual levels. The behaviour, movement and dive patterns of nursing females off the south coast of Zanzibar were investigated between January and March 2000 to 2002 and statistical comparisons were made between observations made at different levels of tourist activity. Behavioural data was collected during boat surveys using scan sampling of groups and focal individual follows of 5 female dolphins with calves. The movement patterns of dolphin groups were not affected by the presence of a few (1 to 2) tourist boats without swimmers. However, the groups displayed a significantly larger proportion of erratic (non-directional) movements as tourist activities increased and when swimmers were present. The proportion of active, peduncle, tail-out and porpoise dives also increased as tourist activity increased. Further, females travelled more frequently as tourist activities increased; this may have a negative effect on the time available for females to nurse their calves. Intense non-regulated dolphin tourism in this area may lead to a shift in habitat use by nursing females, and the apparent changes in dolphin behaviour due to the increased levels of tourism may ultimately reduce fitness at both individual and population levels. We urge that the guidelines already issued by the Department of Fisheries and Marine Products, Zanzibar, be implemented and complied with as a first important step towards sustainable dolphin tourism.

Keywords: mammal, Tanzania, marine, swimming/diving, wildlife viewing (boat)

Stephenson, P. J. 1993. The small mammal fauna of Réserve Spéciale d'Analamazaotra, Madagascar: the effects of human disturbance on endemic species diversity. *Biodiversity & Conservation* 2:603–615.

This study represents the first long-term small mammal survey of the mid-altitude rain forest reserve of Analamazaotra, Madagascar. Twenty-three visits were made to the reserve between April 1988 and May 1990. Live-trapping with Sherman and pitfall traps at four sites subjected to varying levels of human disturbance revealed the presence of seven endemic tenrec species, three endemic rodent species and an introduced rat. Greater species richness was demonstrated at the most undisturbed site, though individual species abundance was reduced. Human disturbance associated with tourism was correlated with a decrease in endemic species richness and an increase in abundance of introduced rats. Forest subjected to infrequent logging by local people exhibited an intermediate level of species richness. It is recommended that core areas of the reserve be left undisturbed in order to preserve small mammal species diversity.

Keywords: mammal, Madagascar, forest

Stockin, K. A., D. Lusseau, V. Binedell, N. Wiseman, and M. B. Orams. 2008. Tourism affects the behavioural budget of the common dolphin *Delphinus* sp. in the Hauraki Gulf, New Zealand. *Marine Ecology Progress Series* 355:287–295.

Common dolphins *Delphinus* sp. are frequently targeted by tourism operations in New Zealand waters, yet there is a paucity of data on potential impacts faced by this species. Transition matrix models, used widely in population ecology, have recently been applied to behavioural transitions in order to provide successful management guidelines. We detail the use of Markov chain models to assess the impact of tourism activities on the behavioural state of common dolphins in the Hauraki Gulf, New Zealand. First-order time discrete Markov chain models were used to describe transition probabilities in both control and impact scenarios. The effect of boat interactions was quantified by comparing transition probabilities of both control and impact chains. Foraging and resting bouts were significantly disrupted by boat interactions to a level that raises concern about the sustainability of this impact. Both the duration of bouts and the overall time spent in these 2 behavioural states decreased. Foraging dolphins took significantly longer to return to their initial behavioural state in the presence of the tour boat. There was also an increased preference to shift behaviour to socialising or milling after tour boat interactions. Impacts identified in the present study are similar to those previously reported for bottlenose dolphins, a coastal species typically considered to be more susceptible to cumulative anthropogenic impacts.

Keywords: mammal, New Zealand, marine, wildlife viewing (boat)

Storch, I., and C. Leidenberger. 2003. Tourism, mountain huts and distribution of corvids in the Bavarian Alps, Germany. *Wildlife Biology* 9:301–308.

Anthropogenic resources related to recreational activities and tourism infrastructure may greatly affect wildlife species in the Alps. In this paper, we explore the effects of mountain tourism in the Bavarian Alps, Germany, on the spatiotemporal distribution of corvids in the post-fledging period in summer and autumn. We contrast corvid point-counts in the surroundings of 28 popular mountain huts (hut areas) with those in 22 similar areas rarely visited by humans (control areas). Carrion crows (*Corvus corone*) and magpies (*Pica pica*) were exclusively observed at huts, and jays (*Garrulus glandarius*) occurred in more hut areas than in controls.

Alpine choughs (*Pyrrhocorax graculus*), jays and nutcrackers (*Nucifraga caryocatactes*) were more numerous at huts than in control areas. Ravens (*Corvus corax*) were equally common, but like Alpine choughs, they spent more time foraging in hut than in control areas. Multivariate analyses confirmed that corvid incidence was significantly related to tourist use. However, corvids visited huts regardless of the actual number of humans present. Our results suggest that corvids opportunistically adjust their range use to the availability of resources offered by tourism. Mountain huts and other places frequented by humans may thus contribute to an increased carrying capacity for corvids at higher elevations. This may have major ramifications for other species that corvids prey upon or compete with. Mountain tourism in the Alps may thus conflict with conservation efforts for threatened species such as grouse (Tetraonidae)

Keywords: bird, Germany, agricultural, forest, grassland, hiking

Swarthout, E. C. H., and R. J. Steidl. 2003. Experimental effects of hiking on breeding Mexican spotted owls. *Conservation Biology* 17:307–315.

Abstract: On the Colorado Plateau, some environments occupied by Mexican Spotted Owls (*Strix occidentalis lucida*) receive a great deal of recreational use. To assess the effects of hikers on breeding owls, we quantified changes in the activity budgets of owls at nests in response to a controlled amount of hiking in canyons of southern Utah in 1997 and 1998. We examined differences in the duration and frequency of eight behaviors as well as in the type and frequency of owl vocalizations between hiking and control treatments. In general, activity budgets of owls did not change markedly when hikers were near nests, although during hiking treatments, females decreased the amount of time they handled prey by 57% and decreased the amount of time they performed daytime maintenance behaviors by 30%. Further, hikers caused both females and males to increase the frequency of contact vocalizations by 58% and 534%, respectively. The order in which we applied treatments at nests (control-hiking or hiking-control) also influenced owl responses to hiking treatments, suggesting that observers near nests may have affected owl behavior. We concluded that the cumulative effects of high levels of short-duration recreational hiking near nests may be detrimental to Mexican Spotted Owls. Given current levels of visitation rates to most remote canyons occupied by owls, however, owl populations on the Colorado Plateau are not likely threatened by hiking. Notable exceptions are those canyons that receive use by ≥ 50 hikers per day. We recommend monitoring of owl occupancy, nest success, and hiking intensity in these high-use canyons.

Keywords: bird, United States, hiking

Tadesse, S. A., and B. P. Kotler. 2012. Impact of tourism on Nubian Ibex (*Capra nubiana*) revealed through assessment of behavioral indicators. *Behavioral Ecology* 23:1257–1262.

Behavioral indicators can provide critical information to conservation managers. Here we apply behavioral indicators based on foraging theory to quantify the effect of tourists on the critically endangered Nubian ibex (*Capra nubiana*). Ibex are habituated to human presence in En Avdat National Park, Israel; nevertheless, they exhibit heightened wariness of humans especially during the kidding season or when far from escape terrain. We applied behavioral indicators through the measurement of giving-up-densities (GUD, the amount of food that a forager leaves behind in a resource patch) and vigilance behavior to investigate the spatial and temporal variation in the patch use behavior of Nubian ibex under the influence of tourism. We hypothesized that Nubian ibex should treat the presence of tourists in a similar manner to the risk of predation. Our results show that the impact of tourism on ibex significantly varied both temporally and spatially in response to tourist

activity. In regard to the temporal variation, ibex had higher GUDs on weekends when tourist activity was high than on weekdays. Furthermore, ibex GUDs were highest in the habitat most frequented by tourists, but only at times of high tourist activity. In a second experiment, the presence of tourists in close proximity always caused Nubian ibex to increase their GUDs in resource patches, even on a steep slope. The spatial position of the tourists up slope or down slope from the ibex affected both GUDs and vigilance behavior. The response was especially sharp when the tourists disturbed ibex from up slope, blocking escape lines. Even for this apparently well-habituated population of ibex, tourist presence significantly increased foraging costs as revealed by behavioral indicators. This study demonstrates how applying methods from behavioral ecology to conservation problems allows access to useful information that may be difficult to obtain using other approaches.

Keywords: mammal, Israel

Taylor, A. R., and R. L. Knight. 2003. Wildlife responses to recreation and associated visitor perceptions. *Ecological Applications* 13:951–963.

Outdoor recreation has the potential to disturb wildlife, resulting in energetic costs, impacts to animals' behavior and fitness, and avoidance of otherwise suitable habitat. Mountain biking is emerging as a popular form of outdoor recreation, yet virtually nothing is known about whether wildlife responds differently to mountain biking vs. more traditional forms of recreation, such as hiking. In addition, there is a lack of information on the “area of influence” (within which wildlife may be displaced from otherwise suitable habitat due to human activities) of different forms of recreation. We examined the responses of bison (*Bison bison*), mule deer (*Odocoileus hemionus*), and pronghorn antelope (*Antilocapra americana*) to hikers and mountain bikers at Antelope Island State Park, Utah, by comparing alert distance, flight distance, and distance moved. Within a species, wildlife did not respond differently to mountain biking vs. hiking, but there was a negative relationship between wildlife body size and response. We determined the area of influence along trails and off-trail transects by examining each species' probability of flushing as perpendicular distance away from a trail increased. All three species exhibited a 70% probability of flushing from on-trail recreationists within 100 m from trails. Mule deer showed a 96% probability of flushing within 100 m of recreationists located off trails; their probability of flushing did not drop to 70% until perpendicular distance reached 390 m. We calculated the area around existing trails on Antelope Island that may be impacted by recreationists on those trails. Based on a 200-m “area of influence,” 8.0 km (7%) of the island was potentially unsuitable for wildlife due to disturbance from recreation. Few studies have examined how recreationists perceive their effects on wildlife, although this has implications for their behavior on public lands. We surveyed 640 backcountry trail users on Antelope Island to investigate their perceptions of the effects of recreation on wildlife. Approximately 50% of recreationists felt that recreation was not having a negative effect on wildlife. In general, survey respondents perceived that it was acceptable to approach wildlife more closely than our empirical data indicated wildlife would allow. Recreationists also tended to blame other user groups for stress to wildlife rather than holding themselves responsible. The results of both the biological and human-dimensions aspects of our research have implications for the management of public lands where the continued coexistence of wildlife and recreation is a primary goal. Understanding wildlife responses to recreation and the “area of influence” of human activities may help managers judge whether wildlife populations are experiencing stress due to interactions with humans, and may aid in tailoring recreation plans to minimize long-term effects to wildlife from disturbance. Knowledge of recreationists' perceptions and beliefs regarding their effects on wildlife may also assist public lands managers in encouraging positive visitor behaviors around wildlife.

Keywords: mammal, United States, grassland, scrub/shrub, biking, hiking

Thiel, D., S. Jenni-Eiermann, V. Braunisch, R. Palme, and L. Jenni. 2008. Ski tourism affects habitat use and evokes a physiological stress response in capercaillie *Tetrao urogallus*: a new methodological approach. *Journal of Applied Ecology* 45:845–853.

* 1 Human outdoor recreational activities are increasing and have a significant impact on wildlife. There are few methods suitable for investigating the response of rare and endangered species to human recreational activities, although the impact can be assessed at various scales by measuring both physiological and behavioural responses to disturbance. * 2 Capercaillie *Tetrao urogallus* are suffering strong population declines throughout central Europe. We examined the effects of ski tourism on capercaillie habitat use and adrenocortical activity, measured non-invasively in droppings. * 3 During three winters, 2003–06, we radio-tracked 13 capercaillie. In the southern Black Forest in Germany, we sampled 396 droppings of these and additional individuals before and after the start of the ski season. We tested whether the intensity of human winter recreational activities affected home range location and habitat use, and we identified those factors influencing the concentration of corticosterone metabolites (CM) in droppings. * 4 Capercaillie used habitats subject to ski tourism. Although the latter did not affect home range location, capercaillie preferred undisturbed forests within their home ranges and avoided areas with high recreation intensity in the ski season. Faecal CM levels of individuals in areas with low recreation intensity were significantly lower than those in areas with moderate or high recreation intensity during the entire study period. * 5 We conclude that ski tourism affects both habitat use and endocrine status in capercaillie, with potential negative consequences on body condition and overall fitness. * 6 Synthesis and applications. This study demonstrates the relevance of studying wildlife responses at various temporal and spatial scales, and the value of using multiple methods applied to the same individuals to monitor the impact of human recreational activities on a free-ranging species. In order to protect capercaillie populations, we recommend that managers keep forests inhabited by capercaillie free from tourism infrastructure and retain undisturbed forest patches within skiing areas.

Keywords: bird, Germany, agricultural, forest, alpine ski/snowboard, snowshoeing, xc skiing

Thiel, D., E. Ménoni, J.-F. Brenot, and L. Jenni. 2007. Effects of Recreation and Hunting on Flushing Distance of Capercaillie. *Journal of Wildlife Management* 71:1784–1792.

* 1 Human outdoor recreational activities are increasing and have a significant impact on wildlife. There are few methods suitable for investigating the response of rare and endangered species to human recreational activities, although the impact can be assessed at various scales by measuring both physiological and behavioural responses to disturbance. * 2 Capercaillie *Tetrao urogallus* are suffering strong population declines throughout central Europe. We examined the effects of ski tourism on capercaillie habitat use and adrenocortical activity, measured non-invasively in droppings. * 3 During three winters, 2003–06, we radio-tracked 13 capercaillie. In the southern Black Forest in Germany, we sampled 396 droppings of these and additional individuals before and after the start of the ski season. We tested whether the intensity of human winter recreational activities affected home range location and habitat use, and we identified those factors influencing the concentration of corticosterone metabolites (CM) in droppings. * 4 Capercaillie used habitats subject to ski tourism. Although the latter did not affect home range location, capercaillie preferred undisturbed forests within their home ranges and avoided areas with high recreation intensity in the ski season. Faecal CM levels of individuals in areas with low recreation intensity were significantly lower than

those in areas with moderate or high recreation intensity during the entire study period. * 5We conclude that ski tourism affects both habitat use and endocrine status in capercaillie, with potential negative consequences on body condition and overall fitness. * 6Synthesis and applications. This study demonstrates the relevance of studying wildlife responses at various temporal and spatial scales, and the value of using multiple methods applied to the same individuals to monitor the impact of human recreational activities on a free-ranging species. In order to protect capercaillie populations, we recommend that managers keep forests inhabited by capercaillie free from tourism infrastructure and retain undisturbed forest patches within skiing areas.

Keywords: bird, Germany, France, forest, alpine ski/snowboard, hiking, xc skiing

Thomas, K., R. G. Kvitek, and C. Bretz. 2003. Effects of human activity on the foraging behavior of sanderlings *Calidris alba*. *Biological Conservation* **109**:67–71.

Urbanization and coastal development has dramatically reduced the beach habitat available for foraging shorebirds worldwide. This study tested the general hypothesis that recreational use of shorebird foraging areas adversely affects the foraging behavior of sanderlings *Calidris alba*. Observations conducted on two central California beaches from January through May and September through December of 1999 showed that number and activity of people significantly reduced the amount of time sanderlings spent foraging. Although the sample size was low, the most significant negative factor was the presence of free running dogs on the beach. The experimentally determined minimal approach distance did not vary significantly with the type of human activities tested. Based on these results, policy recommendations for minimizing the impact of human beach activities on foraging shorebirds include: (1) people maintain a minimum distance of 30 m from areas where shorebirds concentrate and (2) strict enforcement of leash laws.

Keywords: bird, United States, beach, beach use, dog-walking, jogging/running

Titus, J. R., and L. W. VanDruff. 1981. Response of the Common Loon to Recreational Pressure in the Boundary Waters Canoe Area, Northeastern Minnesota. *Wildlife Monographs*:3–59.

No abstract

Keywords: bird, United States, forest, freshwater, boating

Tratalos, J. A., and T. J. Austin. 2001. Impacts of recreational SCUBA diving on coral communities of the Caribbean island of Grand Cayman. *Biological Conservation* **102**:67–75.

The impact of recreational SCUBA diving on coral reefs of the Cayman Islands, British West Indies, was assessed from 63 10-m video transects, filmed on reefs in the West Bay area of Grand Cayman. Three high use and three low use dive sites were sampled at distances of c. 15, 55 and 200 m from mooring buoys, in addition to three sites where no diving occurs. Both diver numbers and distance from buoys were found to show highly significant ($P < 0.01$) effects on hard coral cover and cover of the major reef-building coral, *Montastrea annularis*. Diver numbers also increased the amount of dead coral and coral rubble. Relative to overall hard coral cover, the proportion of massive corals was smallest at heavily dived sites, but there was a larger proportion of *Agaricia* spp. corals, dead coral and coral rubble at these sites. Our findings suggest the need for a new management approach if the Islands are to conserve the ecological and aesthetic qualities of their most popular dive sites.

Keywords: invertebrate, Cayman Islands, marine, swimming/diving

Trathan, P. N., J. Forcada, R. Atkinson, R. H. Downie, and J. R. Shears. 2008. Population assessments of gentoo penguins (*Pygoscelis papua*) breeding at an important Antarctic tourist site, Goudier Island, Port Lockroy, Palmer Archipelago, Antarctica. *Biological Conservation* **141**:3019–3028.

Goudier Island is located in the Palmer Archipelago, to the west of the Antarctic Peninsula; it is one of the most frequently visited tourist sites in Antarctica. A number of gentoo penguin (*Pygoscelis papua*) breeding colonies are located on the island and these have been the focus of one of the longest running experiments to examine the impacts of tourist numbers upon penguin breeding performance anywhere in the Antarctic. In this paper we describe the population trends and breeding productivity (chicks per nest) of the 10 colonies on Goudier Island, all of which have now been monitored for 12 consecutive years beginning in the 1996/1997 breeding season. Our results demonstrate that all colonies show considerable inter-annual variability for both the number of breeding pairs and breeding productivity. Of the six visited colonies, two showed an important and significant statistical decline in the number of breeding pairs. One of these declining colonies is used to determine the breeding chronology dates for all other colonies, an important part of the monitoring procedure used to assess breeding success. Our results suggest that in the future, it would be useful to control for this additional disturbance. Our results further suggest that understanding all of the many subtle influences that impact upon gentoo penguin breeding numbers is complex and that some factors may never be completely identified.

Keywords: bird, Antarctica, polar, hiking

Trulio, L. A., and J. Sokale. 2008. Foraging Shorebird Response to Trail Use Around San Francisco Bay. *Journal of Wildlife Management* **72**:1775–1780.

We studied how human use of trails affected foraging shorebirds over 24 months at 3 locations around San Francisco Bay, California, USA. By observing sites with trails and nearby sites without trails, we assessed whether numbers of trail users had an effect on the number of birds, species richness, or proportion of shorebirds foraging on tidal mudflats. Human use at non-trail sites averaged <1 person/hour, whereas use at trail sites averaged 68 people/hour. Despite these differences, we found no negative effects of trail use on the number of birds, species richness, or proportion of birds foraging, either overall or by season, when comparing trail to non-trail sites. Human use of trail sites on higher use days (typically weekends) averaged about 2.5 times the level on lower use days (typically weekdays). When comparing bird response on paired lower and higher use days at the trail sites, we found the number of shorebirds decreased with increasing trail use ($F_{1,119} = 4.20$, $P = 0.043$), with higher trail-use days averaging 25% fewer birds than on lower use days. Although managers may allow human use of trails adjacent to shorebird foraging areas under some conditions, high levels of trail use may negatively affect birds, making it essential to offer birds alternative, trail-free foraging opportunities.

Keywords: bird, United States, shoreline

Tsounis, G., L. Martinez, L. Bramanti, N. Viladrich, J. Gili, A. Martinez, and S. Rossi. 2012. Anthropogenic effects on reproductive effort and allocation of energy reserves in the Mediterranean octocoral *Paramuricea clavata*. *Marine Ecology Progress Series* **449**:161–172.

In order to better understand the sources, patterns and consequences of anthropogenic effects on populations of the Mediterranean gorgonian *Paramuricea clavata*, we examined the proportion of injured colonies among populations exposed to a combination of anthropogenic disturbances (recreational cast fishing, commercial lobster pots, gill nets and SCUBA diving), as well as the physiological response of injured corals. Between 10 and 33% of the colonies in unprotected populations were partially colonized by epibionts, most likely following tissue injury, whereas only 4 to 10% of the populations in a marine protected area were affected. Populations that were simultaneously exposed to fishing as well as intensive SCUBA diving showed the highest proportion of colonization. Colonies with approximately 30 to 35% of epibiont coverage showed significantly lower numbers of gonads per polyp. Similarly, concentrations of lipids were lower in females with epibionts, thus indicating allocation of resources into recovery of injured tissue instead of reproduction. Furthermore, whereas unaffected colonies showed a uniform distribution of carbohydrates and proteins through apical branches to more central ones, colonies with epibionts had significantly lower protein concentrations in branches that are positioned 3 branching order levels closer to the stem. The results thus indicate a preference of apical growth in recovering colonies, via a different distribution of food within the colony. Reproductive success in surface-brooding corals growing on walls and overhangs might also be reduced by SCUBA bubbles from divers passing below, as bubbles efficiently remove eggs brooded on colony branches.

Keywords: invertebrate, Spain, marine, swimming/diving

Tuite, C. H., P. R. Hanson, and M. Owen. 1984. Some Ecological Factors Affecting Winter Wildfowl Distribution on Inland Waters in England and Wales, and the Influence of Water-Based Recreation. *Journal of Applied Ecology* 21:41–61.

(1) Multiple regression analyses are used to examine the distribution of nine common freshwater wildfowl in Britain. Six independent variables related to the ecology of inland waters are used in the regression models. (2) The amount of variation accounted for by the regressions varied considerably between species and between months for the same species. The regression coefficients and r^2 values are summarized. The significance of the coefficients is discussed in terms of the migration patterns and feeding ecology of the different species. Most relationships were in concordance with those expected, based on known habits and requirements of the birds. For example, large sites tended to hold more wildfowl than smaller ones and relationships with the crinkliness of the shore were probably due to the fact that many sites are primarily roosts and that large reservoirs have relatively simple perimeters. (3) Chi-squared analyses were used to test the effects of the presence of different types of water-based recreation in terms of the observed number of birds compared to the number predicted by the regression models. The results suggest that winter wildfowl distribution is affected by water-based recreation but the impact on different species varies considerably. There is also substantial variation apparent between activities in terms of their disturbance effect. The most susceptible species to disturbance from recreation were teal, shoveler and goldeneye, whereas the most tolerant were mute swan, tufted duck, pochard and mallard. The greatest deleterious impact on winter wildfowl numbers was associated with the presence of coarse fishing, sailing and rowing. The presence of birdwatching, which is frequently associated with active conservation management, was the commonest activity category associated with higher-than-expected numbers of most species. Shooting was not shown to have great impact, but this was due to the choice by hunters of good wildfowl sites rather than any positive effect. (4) Conditions have been favourable for inland wildfowl in recent years and the fact that most recreation on water is carried out largely in the summer has also meant that the impact of recreational activities has not been as great as was feared. There has been an

increase in public participation in water sports in winter recently and if this trend continues the impact on wildfowl may have to be re-examined.

Keywords: bird, United Kingdom, boating, fishing (boat), wildlife viewing

Tull, J. C., and P. F. Brussard. 2007. Fluctuating Asymmetry as an Indicator of Environmental Stress From Off-Highway Vehicles. *Journal of Wildlife Management* **71**:1944–1948.

With human activities increasingly impacting natural resources in relatively remote locations, there is a need for simple and efficient methods to explore the ecological consequences of these activities. Little is understood about the influences of off-highway vehicle (OHV) use on wildlife populations. We examined the effect of OHV activity on developmental instability in a phrynosomatid lizard (i.e., western fence lizard [*Sceloporus occidentalis*]) in the western Great Basin, USA. We measured fluctuating asymmetry (FA) of bilateral head-scale patterns in populations of lizards at 3 OHV and 3 non-OHV sites. Fluctuating asymmetry was higher at OHV sites relative to non-OHV sites, supporting the idea that OHV activity can stress wildlife populations. We found FA to be a good tool for uncovering responses to stress in natural populations, and we recommend exploring FA as a means of uncovering developmental instability in other systems that merit conservation interest.

Keywords: reptile, United States, desert, motorized (land)

Ulrich, W., M. Zalewski, I. Hajdamowicz, M. Stańska, W. Ciurzycki, and P. Tykarski. 2010. Tourism disassembles patterns of co-occurrence and weakens responses to environmental conditions of spider communities on small lake islands. *Community Ecology* **11**:5–12.

The impact of disturbance on animal and plant assemblages has been described mainly in terms of aggregate community properties like species richness, abundance, or productivity. However, the question how disturbance acts on species interactions, particularly on patterns of co-occurrence, has received much less attention. Here we use a large pitfall trap sample of spiders from two complexes of lake islands in Northern Poland to show how disturbance by tourist visits affects species richness, composition and co-occurrence. On the pristine and protected islands of Lake Wigry, species co-occurrence was significantly segregated. Further, island species richness and abundances could be predicted from environmental correlates, particularly from island area, soil fertility and humidity. In turn, on the lake islands that are frequently visited by tourists, species co-occurrences were random and environmental correlates other than island area failed to predict species richness and abundances. However, species composition, α -, β -, and γ -diversities, as well as average local spider abundances did not significantly differ between both island complexes. Our results show that disturbance disassembles the structure of spider communities prior to visible richness and abundance effects. This result has implications for biological conservation. The detection of community disassembly might be an early sign for factors that act negatively on ecosystem functioning.

Keywords: invertebrate, Poland, forest, freshwater

Uyarra, M. C., and I. M. Côté. 2007. The quest for cryptic creatures: Impacts of species-focused recreational diving on corals. *Biological Conservation* **136**:77–84.

Coral reefs are popular with ecotourists, but the impact of divers on reefs is cause for concern. In this study, we assessed the damage to corals caused by divers seeking cryptic but charismatic fish such as seahorses (family Syngnathidae) and frogfishes (Antennariidae), which are found on reefs around the world. These fish are closely associated with the reef substratum, thus bringing divers into close proximity to coral. We found that when in the vicinity of frogfish and seahorses, divers made unintentional contact with corals significantly more often and for longer periods than when these species were absent. This change in diver behaviour resulted in a greater frequency of coral breakage and scarring at seahorse/frogfish sites than at ecologically equivalent control sites. However, the spatial extent of damage appeared limited. Beyond 1–3 m from the seahorse or frogfish, coral breakage and scarring rate decreased to levels similar to those of control sites. None of the coral species, which suffered the most damage, was particularly rare, suggesting that the habitat conservation concern of these marked shifts in diver behaviour is limited. Nevertheless, the use of pre-dive briefings and smaller dive group sizes could minimise the damage caused by divers approaching cryptic species of interest near the reef.

Keywords: invertebrate, Bonaire, marine, swimming/diving

Van der Zande, A. N., J. C. Berkhuisen, H. C. van Latesteijn, W. J. ter Keurs, and A. J. Poppelaars. 1984. Impact of outdoor recreation on the density of a number of breeding bird species in woods adjacent to urban residential areas. *Biological Conservation* **30**:1–39.

Outdoor recreation is often supposed to have an important impact on wildlife, although this assumption has not been tested very often. The resulting lack of knowledge becomes apparent in situations where parties with conflicting interests disagree on the number of visitors an area can sustain without major repercussions. In 1980 the possible effects of recreation intensity upon bird densities were studied in seven study plots adjacent to urban residential areas in The Netherlands. Of the 31 bird species found, only 13 could be studied in detail, being present in at least 20 territories. Significant negative correlations between recreation intensities and bird densities were found for 8 of these 13 species. The slopes of the regression lines enabled us to rank the 8 species in a sequence of decreasing susceptibility. The results indicate that the disturbance is caused rather by the recreation intensity during the week than by the recreation intensity at weekends.

Keywords: bird, The Netherlands, forest

Van der Zande, A. N., and P. Vos. 1984. Impact of a Semi-experimental increase in recreation intensity on the densities of birds in groves and hedges on a lake shore in The Netherlands. *Biological Conservation* **30**:237–259.

The possibility of disturbance of birds by outdoor recreation is often mentioned, but has rarely been studied. This article presents the results of a disturbance field experiment which took place during three breeding seasons and was conducted along a 4.5 km long lake shore with hedges and groves. Parts of this area have probably undergone an increase in visitor numbers since 1979 as a result of the construction and opening of a car park nearby. The recreation intensity in other parts further away from the car park has probably not increased. Visitors and the breeding birds were counted during the breeding seasons in 1977 and 1978 (before the car park was opened) and in the breeding season in 1980 (after the car park had been opened). All but one (*Phylloscopus trochilus*) of the 12 (most abundant) species showed a negative difference between experimental units and control units, indicating a disturbance effect. However, no significance was reached with regard to the following bird species analysed: *Columba palumbus*, *Troglodytes troglodytes*, *Prunella modularis*, *Turdus*

philomelos, *Turdus merula*, *Hippolais icterina*, *Sylvia atricapilla*, *Sylvia borin*, *Sylvia communis*, *Sylvia curruca*, *Phylloscopus trochilis*, *Phylloscopus collybita*. The number of 11 negative differences out of 12, on the contrary, is highly significant using a sign test ($p = 0.003$). Interpreting the results as a recreation effect is also supported by the fact that species show negative correlations between recreation intensity and density in 1980 ($p = 0.033$; sign test). These correlations were significant for *Hippolais icterina* and *Sylvia borin*. Such correlations were not found for 1977 or 1978.

Keywords: bird, The Netherlands, beach, grassland, shoreline

Velando, A., and I. Munilla. 2011. Disturbance to a foraging seabird by sea-based tourism: Implications for reserve management in marine protected areas. *Biological Conservation* **144**:1167–1174.

The provision of recreational opportunities is one of the important human goals of marine protected areas. However, as levels of recreational use increase, human disturbance is likely to cause significant detrimental effects upon wildlife. Here we evaluate the best managing options to mitigate the impact of sea-based tourism on the foraging activity of an endangered population of European shags, *Phalacrocorax aristotelis*, in a coastal marine protected area (Cíes islands, north-western Iberia). Boat disturbance elicited a characteristic avoidance behavior that resulted in a substantial reduction in foraging activity as levels of boat use increased. Moreover, boats excluded shags from the best feeding areas, resulting in higher densities of foragers in areas of little boat traffic. We used a behavioral model to explore the effects of managing strategies aimed at reducing the impact of boats on the foraging activity of shags. Our model suggested that in low boat disturbance scenarios limiting the number of boats using the reserve would be a better management option than habitat protection (i.e. the establishment of set-aside areas free of boat traffic). On the contrary, when boat disturbance levels are high the protection of habitat is recommendable, even if spatial variation in habitat quality is unknown or poorly assessed. Our study stresses the point that management strategies to minimize disturbance to foraging seabirds may depend on the spatial overlap between sea-based recreational activities and foraging seabirds and the spatial variation in marine habitat quality for seabirds.

Keywords: bird, Spain, marine, shoreline, boating, motorized (boat)

Veloso, V. G., E. S. Silva, C. H. S. Caetano, and R. S. Cardoso. 2006. Comparison between the macroinfauna of urbanized and protected beaches in Rio de Janeiro State, Brazil. *Biological Conservation* **127**:510–515.

The intertidal macroinfauna of five sandy beaches with similar morphodynamics conditions was studied to compare composition and structure between beaches near urbanized centers and protected beaches located in Rio de Janeiro State. The beaches were sampled in winter 1996 and summer 1997 according to a systematic design with stratification. A total of nine species were identified with the crustaceans being the most abundant and frequent animals. Species richness showed little variation between beaches while density of some species such as *Emerita brasiliensis* (Crustacea) and *Phaleria testacea* (Insecta) were lower at urbanized beaches when compared to protected ones. At the most urbanized beaches, *Pseudorchestoidea brasiliensis* was absent during both sampling periods. The negative relationships between human recreational activities (e.g., trampling) and density of macroinfaunal species was recently gained support and in Barra da Tijuca beach these relation is very clear. In the developed and most-visited sector, Barra (Alvorada), the amphipod *Pseudorchestoidea brasiliensis* was never collected whereas in the protected portion, Barra (Reserva), the same species occurred in

high densities. Thus, our results suggested that the amphipod *Pseudorchestoidea brasiliensis* is more vulnerable to trampling than are other species.

Keywords: invertebrate, Brazil, beach, urban, beach use

Walker, B. G., P. D. Boersma, and J. C. Wingfield. 2005. Physiological and behavioral differences in Magellanic penguin chicks in undisturbed and tourist-visited locations of a colony. *Conservation Biology* **19**:1571–1577.

Studies examining anthropogenic effects on wildlife typically focus on adults and on behavioral responses rather than the physiological consequences of human disturbances. Here we examined how Magellanic Penguin (*Spheniscus magellanicus*) chicks living in either tourist-visited or undisturbed areas of a breeding colony were affected by human visitation by comparing the baseline and stress-induced levels of corticosterone during three periods of the breeding season. Newly hatched chicks in visited areas had higher corticosterone stress responses than newly hatched chicks in undisturbed areas ($p = 0.007$), but baseline levels were similar ($p = 0.61$). By 40–50 days of age and around fledging time, both visited and undisturbed chicks showed a robust corticosterone stress response to capture. Tourist-visited chicks did not flee when approached by humans, however, whereas undisturbed chicks fled significantly sooner (i.e., when approached no closer than 9 m; $p < 0.0001$). Although it is unknown whether Magellanic Penguin chicks raised in visited areas suffer negative consequences from the elevation of the corticosterone stress response at hatching, they do exhibit behavioral habituation to human contact by the time they are ready to fledge. Unlike adults living in tourist areas, however, fledging chicks in visited areas do not have a decreased stress response to capture and restraint. Our results show that the coupling of behavioral and physiological habituation in Magellanic Penguins is complex and life-history context may greatly affect the ability of wildlife to adapt to anthropogenic disturbances.

Keywords: bird, Argentina, hiking, wildlife viewing (land)

Walker, B. G., P. Dee Boersma, and J. C. Wingfield. 2006. Habituation of adult magellanic penguins to human visitation as expressed through behavior and corticosterone secretion. *Conservation Biology* **20**:146–154.

Ecotourism is increasing worldwide; hence, it is important to know how wildlife are affected behaviorally and physiologically by human visitation. We studied the effects of human visitation on the Magellanic Penguins (*Spheniscus magellanicus*) at Punta Tombo, Argentina, by monitoring changes in defensive head turns and plasma corticosterone (a hormone secreted in response to stress) for penguins with and without a history of tourist visitation. Habituation to human visitation was rapid. In penguins with no previous exposure to tourists, the number of defensive head turns and level of plasma corticosterone decreased significantly within 5 days of one 15-minute visit/day. Penguins living in tourist-visited and undisturbed areas secreted more corticosterone when captured and restrained than penguins visited by a person. Penguins in tourist areas, however, did not show as strong a corticosterone response to capture and restraint as did penguins in areas without tourists. This difference was due to a decreased capability of the adrenocortical tissue to secrete corticosterone in tourist-visited birds. Although our data show no direct negative effects of tourism on Magellanic Penguins at Punta Tombo, consequences of a modification of physiological capabilities (e.g., adrenocortical function) may not become apparent until much later in life. The physiological differences

between tourist-visited and undisturbed groups of Magellanic Penguins emphasize the importance of monitoring the effects of anthropogenic disturbances on wildlife at multiple levels.

Keywords: bird, Argentina, shoreline, hiking, wildlife viewing (land)

Weinrich, M., and C. Corbelli. 2009. Does whale watching in Southern New England impact humpback whale (*Megaptera novaeangliae*) calf production or calf survival? *Biological Conservation* **142**:2931–2940.

There is growing concern about the effects of wildlife tourism on biologically important parameters in target species and/or populations. We tested whether whale watch vessel exposure affected either the calving rates or calf survival to age 2 in humpback whales (*Megaptera novaeangliae*) on their feeding grounds off of southern New England, where individually identified whales have been studied intensively for decades and whale watch pressure is intense. Whale watch exposure did not correlate with either the calving rate (# of calves/# of years sighted) or calf production and survival of individual females, although a breakpoint analysis showed a slight negative trend up to 1649 min (or 20 boat interactions). In some comparisons, whales with more exposure were significantly more likely to produce calves and to have those calves survive. Logistic regressions including exposure and prey variables also failed to show negative effects of exposure in predicting calf productivity or survival. A limited comparison of calves seen only in an alternate habitat without whale watching showed similar return rates to those in the exposed area. Our data include limited suggestions that some animals (i.e., females alive when whale watching started) might be more susceptible to impacts than others. However, we found no direct evidence for negative effects of whale watch exposure, and suggest that short-term disturbance may not necessarily be indicative of more meaningful detrimental effects on either individuals or populations.

Keywords: mammal, United States, marine, wildlife viewing (boat)

Williams, R., and E. Ashe. 2007. Killer whale evasive tactics vary with boat number. *Journal of Zoology* **272**:390–397.

Controlled exposure experiments that measure animal response to vessels can inform relevant wildlife-viewing guidelines and reveal how they make decisions about changes in their environment. Previous experimental studies documented stereotyped avoidance responses by killer whales to boats. Additional observations collected during these studies showed an apparent shift in avoidance behaviour at high traffic levels. Our study tested experimentally whether whales did respond differently to approach by few (1–3) versus many (>3) vessels. Data were collected in summer 2004 in Johnstone Strait, British Columbia, using a theodolite to track the positions of boats and individually identifiable focal whales during control and treatment (few vs. many boats) phases. The responses of 16 adult male killer whales differed significantly between treatment levels (Wilcoxon's test, $P=0.0148$). Swimming paths became more tortuous when few boats approached whales, but straighter as many boats approached. Pooling treatments would have masked significant responses with high statistical confidence (Wilcoxon's test, $P>0.999$), falsely suggesting that boat presence had no effect. The division between few and many boats was supported by 140 opportunistic observations on 26 whales from a population of 216. We used generalized additive models to control for the effects of confounding variables, detected a non-linear relationship between number of boats and whales' swimming path directness and confirmed an inflection point at approximately three boats within 1000 m. We urge caution when designing controlled exposure assessments that rely on a simple absence–presence framework, which can mask multivariate or non-linear responses. Experimental design, coupled with analytical techniques incorporating statistical power and appropriateness of treatments and response variables, must be considered when

interpreting the biological significance of null findings from impact assessments. Our study provides new information about levels of habitat degradation that this marine apex predator can tolerate.

Keywords: mammal, Canada, marine, wildlife viewing (boat)

Yalden, D. W. 1990. Recreational disturbance of large mammals in the Peak District. *Journal of Zoology* **221**:293–298.

No abstract

Keywords: mammal, United Kingdom

Yalden, P. E., and D. W. Yalden. 1990. Recreational disturbances of breeding golden plovers *Pluvialis apricaria*. *Biological Conservation* **51**:243–262.

Detailed observations were made of golden plovers *Pluvialis apricaria* being disturbed, during the breeding season, by people walking on the moors. During the pre-incubation period, the birds were sensitive to the presence of people within about 200 m, and flew more often. During incubation, golden plovers incubated for 96% of the time, but would have incubated for 98% of the time if they had not been disturbed. They flushed more readily in response to the presence of dogs than people on the moor, and took much longer to resume incubation when people were around. In the post-hatching, chick-guarding, period, adult golden plovers spent about 11% of the observation day reacting to people; they flew more often, increasing their energy expenditure by 15%. Their chicks hid in response to the alarm calls of their parents, so could neither feed nor be brooded. In some cases, parents led their broods away from what had been satisfactory nest sites into quieter areas of moor, and encountered considerable resistance from the neighbours whose territories they invaded.

Keywords: bird, England, grassland, wetland, hiking, dog-walking

Zakai, D., and N. E. Chadwick-Furman. 2002. Impacts of intensive recreational diving on reef corals at Eilat, northern Red Sea. *Biological Conservation* **105**:179–187.

Coral reefs at Eilat, northern Red Sea, are among the most heavily used in the world for recreational diving, with >250,000 dives per year on only 12 km of coastline. We assessed patterns of dive frequency, diver behavior, and coral damage on selected reefs at Eilat, in order to determine impacts of diving tourism. Frequencies and types of recreational SCUBA dives varied widely between 12 coral reef sites, with >30,000 dives per year at the most heavily-used sites. Field observations of diver behavior revealed ca 10 incidents of reef contact per dive, mostly via raising of sediments onto the reef, but also involving direct breakage of corals. The proportion of damaged coral colonies varied significantly with the frequency of SCUBA diving, and did not depend upon site topography. We conclude that current rates of recreational diving on some reefs at Eilat are unsustainable, resulting in damage to the majority of stony coral colonies. This study reveals consequences of diving tourism at extremely high levels of use. Our estimate of diver carrying capacity for reefs at Eilat is similar to levels proposed for other reef sites around the world.

Keywords: invertebrate, Israel, marine, swimming/diving

Zielinski, W. J., K. M. Slauson, and A. E. Bowles. 2008. Effects of Off-Highway Vehicle Use on the American Marten. *Journal of Wildlife Management* 72:1558–1571.

Motorized recreation in North American wildlands is increasing, and technological developments in the power and range of vehicles has increased access to high-elevation habitats. The American marten (*Martes americana*) is vulnerable to this disturbance because martens, like other residents of high-elevation forests, are associated with remote wilderness conditions where the presence of motorized vehicles is a recent phenomenon. We evaluated the effects of vehicles at 2 study sites in California, USA, by comparing marten occupancy rates and probabilities of detection in areas where recreational vehicle use is legal and encouraged (use areas) with wilderness areas where vehicles are prohibited (non-use areas). We sampled vehicle occurrence in nearby use and non-use areas using sound level meters and determined marten occurrence using track and camera stations. We also included 2 secondary measures of potential effects of vehicles on martens: sex ratio and circadian pattern of activity. Martens were ubiquitous in use and non-use areas in both study sites, and there was no effect of vehicle use on marten occupancy or probability of detection. We predicted that females might be less common and martens more nocturnal in use than in non-use areas, but neither occurred. Martens were exposed to low levels of disturbance in our study sites. We estimated that a marten might be exposed to 0.5 vehicle passes/hour and that this exposure had the greatest effect on <20% of a typical home range area. Furthermore, vehicle use usually occurred when martens were inactive. We did not measure behavioral, physiological, or demographic responses, so it is possible that vehicles may have effects, alone or in concert with other threats (e.g., timber harvest), that we did not quantify. We encourage additional studies to determine whether other montane species that are year-round residents demonstrate the same response to motorized vehicles.

Keywords: mammal, United States, forest, motorized (land)

Zuberogoitia, I., J. Zabala, J. A. Martínez, J. E. Martínez, and A. Azkona. 2008. Effect of human activities on Egyptian vulture breeding success. *Animal Conservation* 11:313–320.

Habitat loss, electrocution on power poles and persecution by humans are the main threats to birds of prey. Nevertheless, the effects of human disturbance on endangered species are becoming notorious due to the increasing recreational use of the natural environment. We evaluated the effects of human disturbances on Egyptian vulture *Neophron percnopterus* breeding success and developed conservation measures based on minimum distance of effect and buffer areas in a high human density area of northern Spain. A total of 100 breeding attempts of 15 breeding pairs were monitored over 8 years. Human disturbances affected 42 of the breeding attempts. Those disturbances related to and originating in forestry work had the most severe effect on breeding success, being associated with the loss of 100% of 13 breeding attempts, while human disturbances related to free-time activities caused 44% failures in 25 breeding attempts by four pairs, two of them within Natural Parks. The breeding success was significantly less in territories affected by disturbances than in those free of disturbances. Some pairs affected by disturbances changed their nest site, increasing breeding success. Adults were prevented from entering the nest to feed chicks when anyone was detected at an average distance of 307 m, while an average distance of 837.5 m allowed them access. The maximum alert distance was estimated at 605 m and the buffer area was 57 ha. We discuss the application of our results for management schemes and conservation of this species.

Keywords: bird, Spain, forest, biking, hiking, motorized (land), rockclimbing, wildlife viewing (land)

Appendix 2. NCCP reserves included in the expert opinion survey. An asterisk (*) indicates reserves that are also included in the pilot field study.

Reserve	Managing agency
*Barnett Ranch Open Space	County of San Diego
*Black Mountain Open Space Preserve	City of San Diego
*Blue Sky Ecological Reserve	California Dept of Fish & Wildlife, City of Poway
Boden Canyon Ecological Reserve	City of San Diego, California Dept of Fish & Wildlife
Border Field State Park	California Dept of Parks & Recreation
*Boulder Oaks Open Space Preserve	County of San Diego
Carlsbad Highlands Ecological Reserve	California Dept of Fish & Wildlife
*Carmel Mountain Open Space Preserve	City of San Diego
*Crestridge Ecological Reserve	California Department of Fish & Wildlife
Cuyamaca Rancho State Park	California Dept of Parks & Recreation
Daley Ranch Open Space Preserve	City of Escondido
*Del Dios Highlands Open Space Preserve/Elfin Forest Recreational Reserve	County of San Diego, Olivenhain Water District
*Del Mar Mesa	City of San Diego, U.S. Fish & Wildlife Service
El Capitan Reservoir Open Space Preserve	City of San Diego
Hellhole Canyon Preserve	County of San Diego
*Hollenbeck Canyon Wildlife Area	California Department of Fish & Wildlife
*Iron Mountain	City of Poway
Lake Poway Recreation Area	City of Poway
*Los Penasquitos Canyon Preserve	City of San Diego, County of San Diego
Marian Bear Natural Park	City of San Diego
McGinty Mountain Ecological Reserve	California Dept of Fish & Wildlife
*Mission Trails Regional Park	City of San Diego
Oakoasis Preserve	County of San Diego
Otay Mountain Ecological Reserve	California Dept of Fish & Wildlife, Bureau of Land Mangement
Otay Ranch Preserve	County of San Diego, City of Chula Vista
Otay Valley Regional Park	City of San Diego, County of San Diego, City of Chula Vista
Palomar Mountain State Park	California Dept of Parks & Recreation
Plaisted Creek Ecological Reserve	California Dept of Fish & Wildlife
*Ramona Grasslands Preserve	County of San Diego
Rancho Jamul Ecological Reserve	California Dept of Fish & Wildlife
Rose Canyon Open Space	City of San Diego
Sabre Springs	City of San Diego
Santa Ysabel Open Space Preserve	County of San Diego
San Diego Bay National Wildlife Refuge: South San Diego Bay Unit	U.S. Fish & Wildlife Service
San Diego Bay National Wildlife Refuge: Sweetwater Marsh Unit	U.S. Fish & Wildlife Service
*San Diego National Wildlife Refuge	U.S. Fish & Wildlife Service
San Dieguito Lagoon	City of Del Mar, California Dept of Fish & Wildlife

San Elijo Lagoon Ecological Reserve	County of San Diego, California Dept of Fish & Wildlife
San Felipe Valley Wildlife Area	California Dept of Fish & Wildlife
Scripps Miramar Open Space	City of San Diego
*Simon Preserve	County of San Diego
*San Vicente Highlands Open Space Preserve	California Department of Fish & Wildlife
Spring Canyon/Goat Mesa	City of San Diego
Sutherland Reservoir Open Space	City of San Diego
*Sycamore Canyon/Goodan Ranch Preserve	County of San Diego
Sycuan Peak Ecological Reserve	California Dept of Fish & Wildlife
*Tecolote Canyon Natural Park	City of San Diego
Tijuana River Valley Regional Park	County of San Diego
Tijuana Slough National Wildlife Refuge	U.S. Fish & Wildlife Service
Torrey Pines State Natural Reserve	California Dept of Parks & Recreation
Volcan Mountain Wilderness Preserve	County of San Diego
Wilderness Gardens Open Space Preserve	County of San Diego

Appendix 3. Methods for digitizing recreation trails in 19 NCCP reserves in San Diego County. The GIS shapefiles are available as a separate attachment.

Summary

A selection of recreational areas near San Diego (n=19) were surveyed for evidence of trail use using heads-up digitizing methods. Trails were distinguished by their relation to known existing 'primary' trails within classes of spatial hierarchy comparable to stream networks (primary, secondary, and tertiary) based on records from available trail maps. Recreation uses of trails were not determined but evidence of trail use or varied trail characteristics were noted when relevant.

Feature Development and Processing Scales

Trails were determined as non-natural linear features that differ from natural landscape feature patterns (e.g., stream drainage channel) and having a recognizable network pattern connecting them to the larger known trail system, based on existing trail maps. Digitized trails were visually identified from at or less than 1:5000 scales (approximately 1.5m resolution), and were created at no less than 1:2000 (approximately 0.5m resolution) and no greater than 1:1000 (approximately 0.25m resolution) scales using high resolution world imagery from ArcGIS online servers. Trail feature sketches were completed at intersections with trails of differing attribute characteristics (network order, width, confidence rating).

Hierarchy, Confidence and Width

As a general guide, trails were processed hierarchically by referencing existing maps, identifying and creating all primary trails first prior to identifying and creating secondary and tertiary trails. Primary trails were attributed with the greatest confidence ranking (1) and secondary and tertiary trails that were questionable features, or difficult to delineate light use trails were given a lesser degree of confidence ranking (2 or 3, 3 being the least degree of confidence given of any trail). For example, any non-natural feature without a trail network was marked as disjunctive and rated with low confidence (3) due to indiscernible landscape variations where topographical and physiognomic features decrease trail visibility. Trail width was also notated as large (LW: greater than 5 meters), moderate (MW: between 2-5 meters), or narrow (NW: 2 meters or less).

Extent Limits

Park boundaries were used as a guideline for trail inclusion. Trails external to park boundaries were included if they occurred immediately out of park boundaries, serving as an inlet to the park recreation area. Exterior trails were also included where a dense trail network was found adjacent to park boundary or trails meandered in and out of bounds of open space park boundaries. Exterior trails without network of dense trails external to park were clipped at first intersection with another trail or residential feature.

Review and Finishing

Once trail networks were complete for a site, a final visual inspection was completed at 1:5000 or full site scale extents for mis-categorized trails or evidence of missing trails. All trails visible at 1:5000 warranted inspection at 1:2000 scales and were included. Feature geometry was calculated for each trail segment using linear kilometers. All data were processed using ESRI ArcMap 10.1 in the projected coordinate system NAD 1983 StatePlane California VI FIPS 0406 (Feet) and with the spatial projection of Lambert Conformal Conic.

Data source info:

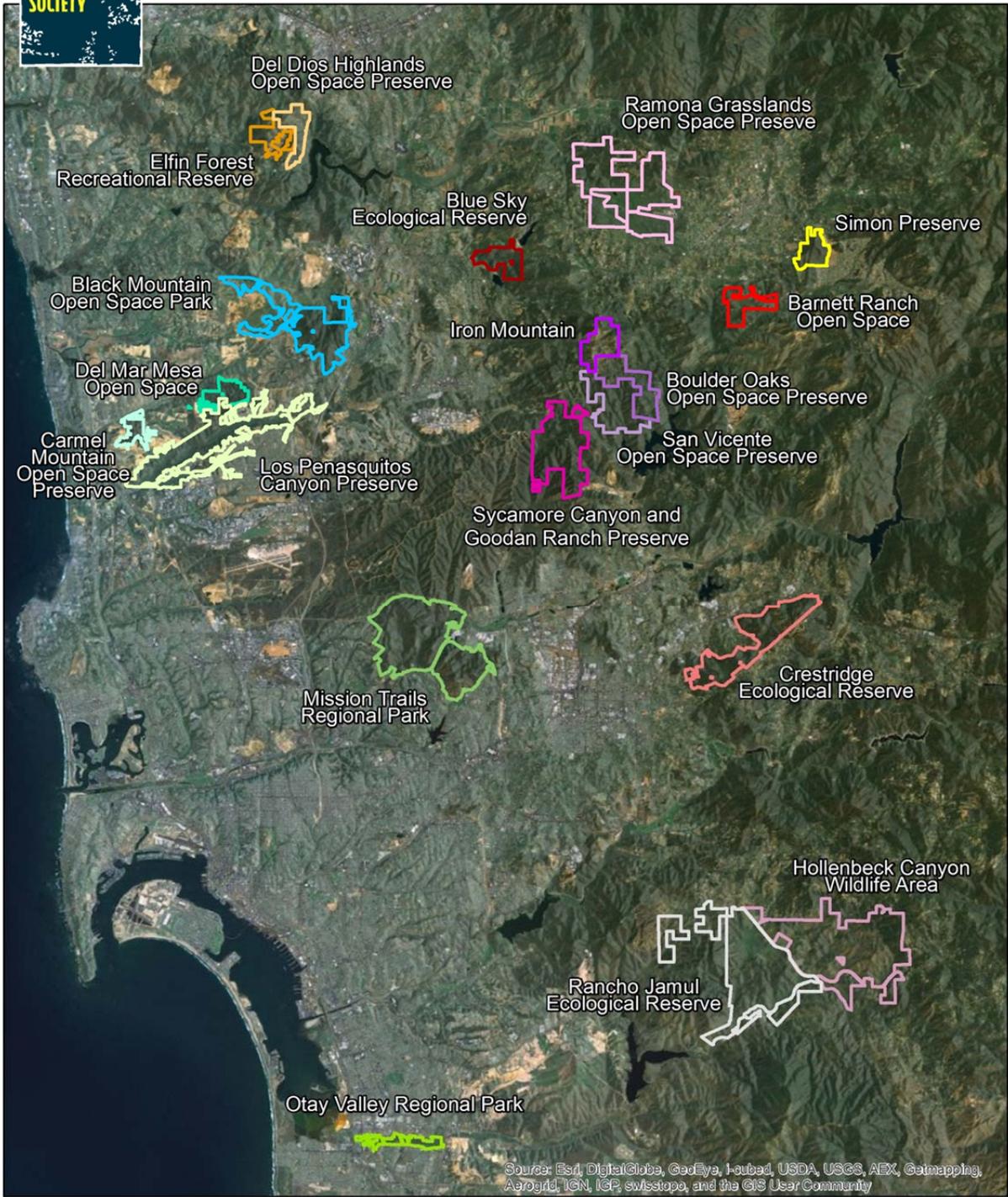
Data Type: ArcGIS Map Service
Connection: Internet
Server: <http://services.arcgisonline.com/ArcGIS/services>
Name: World_Imagery
Map Service Type: Cached
File Format: JPEG
Restriction: Sublayers can't be turned on or off

Cache Scales at 96 DPI:

1:1,128 (1 pixel = 0.298582 m)
1:2,257 (1 pixel = 0.597164 m)
1:4,514 (1 pixel = 1.194329 m)

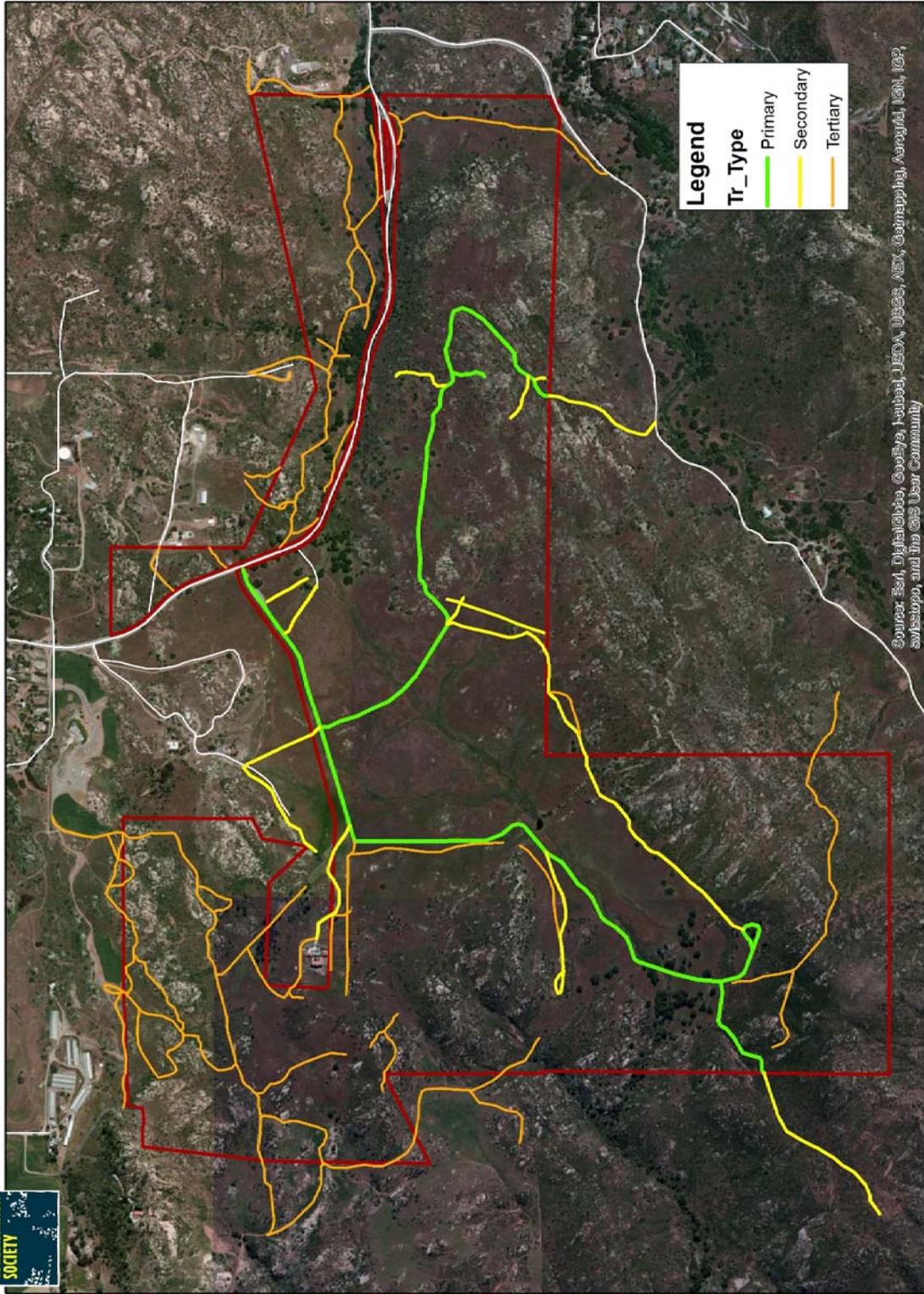


San Diego Trails Site Map



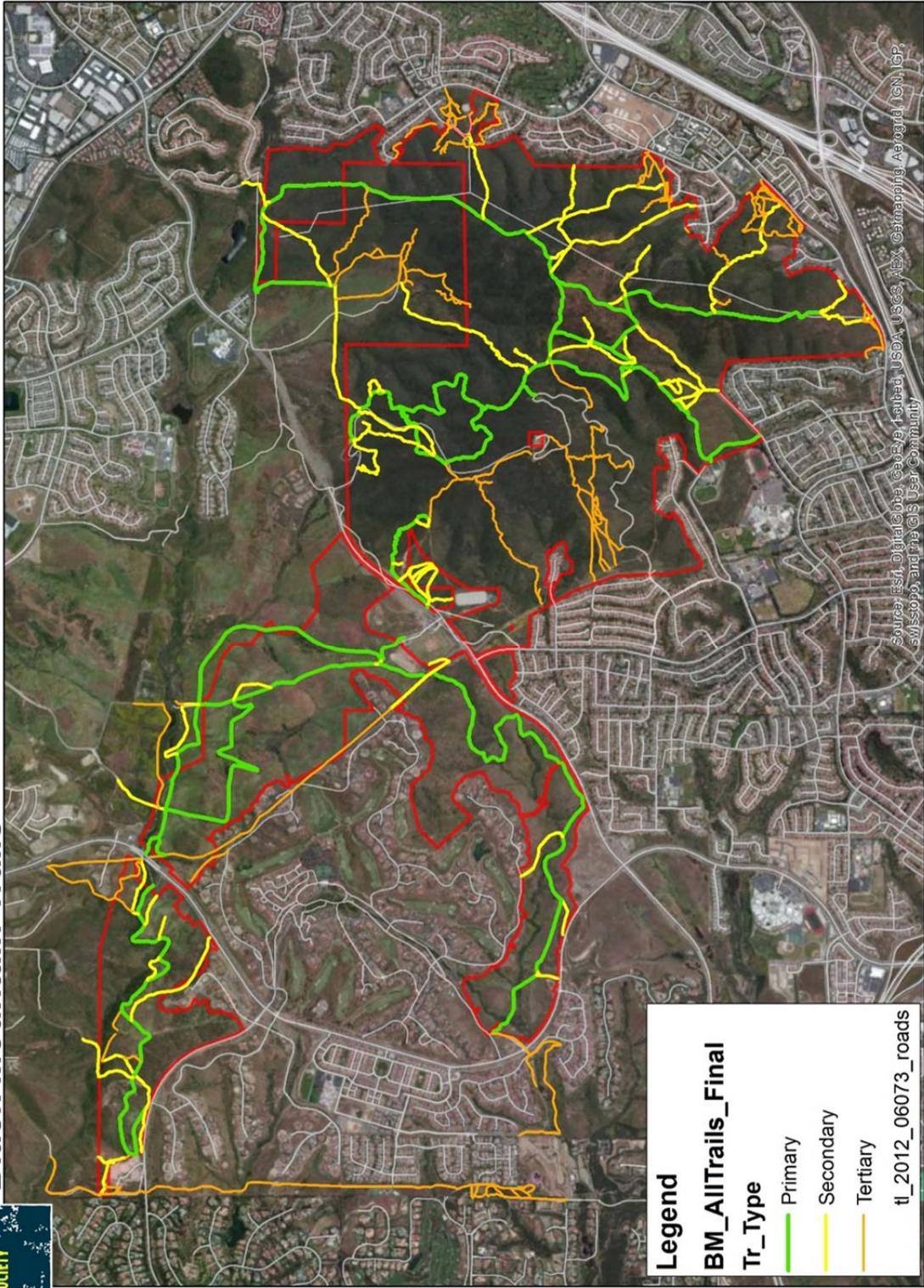


Barnett Ranch Trails



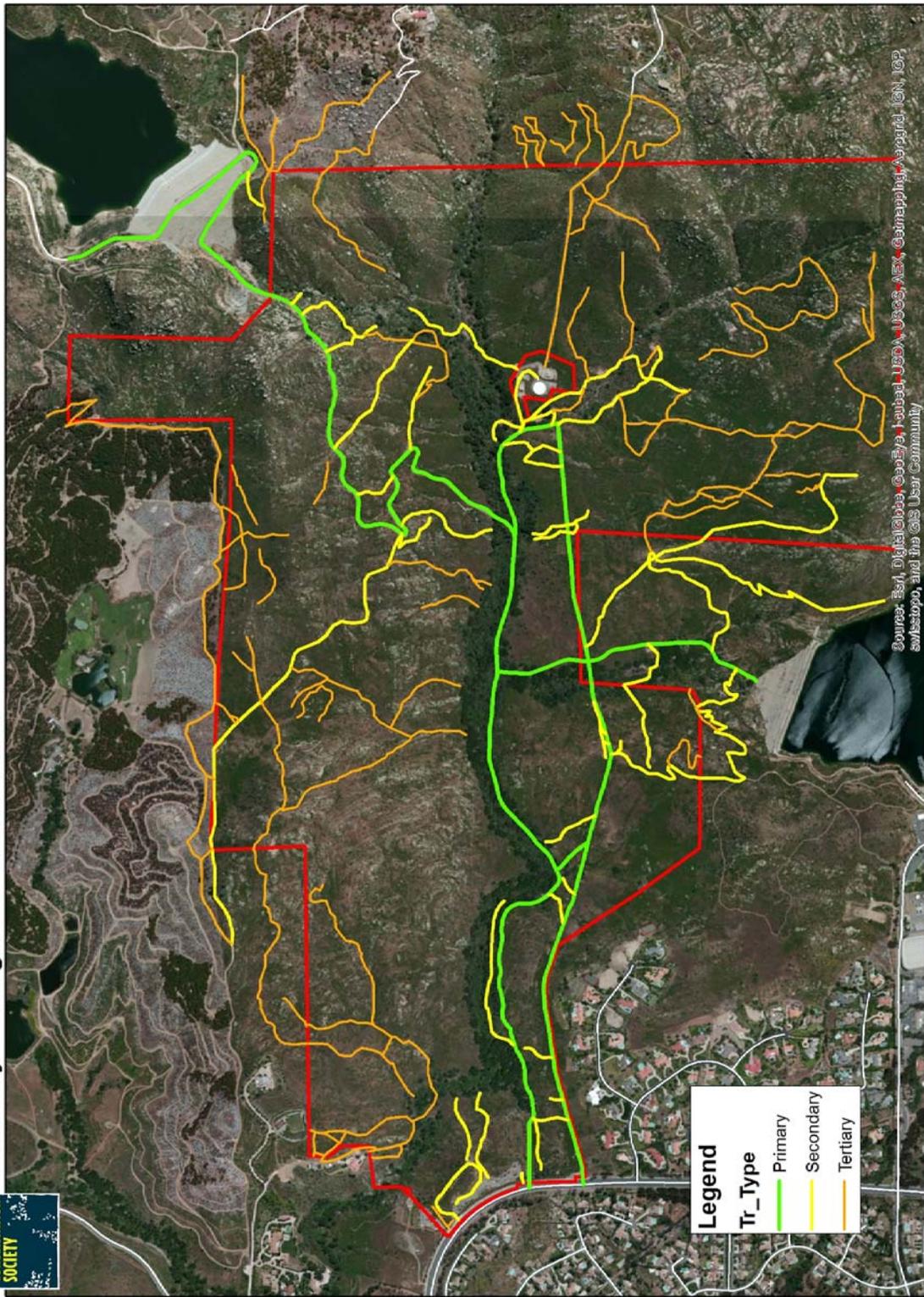


Black Mountain Trails



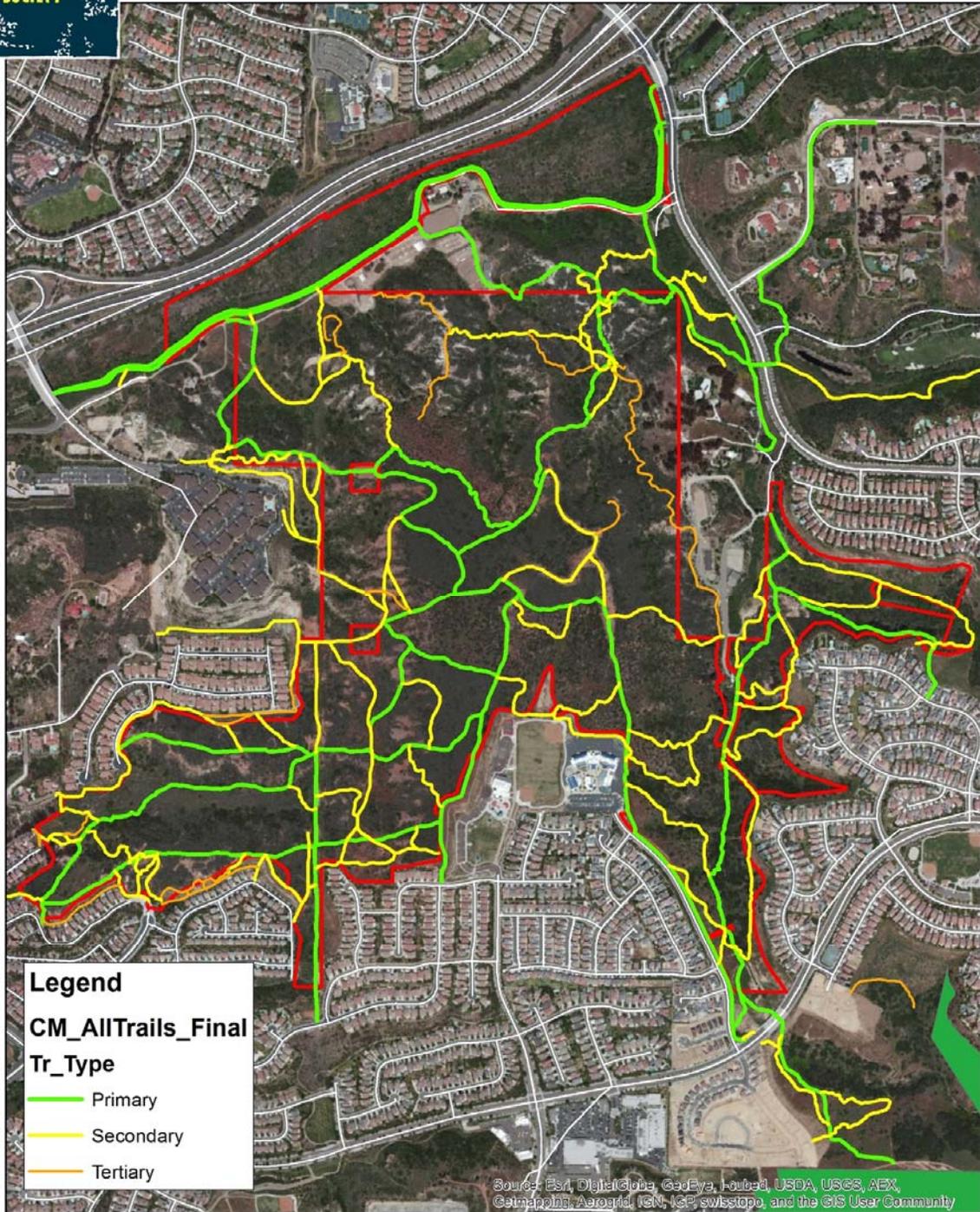


Blue Sky Ecological Reserve Trails





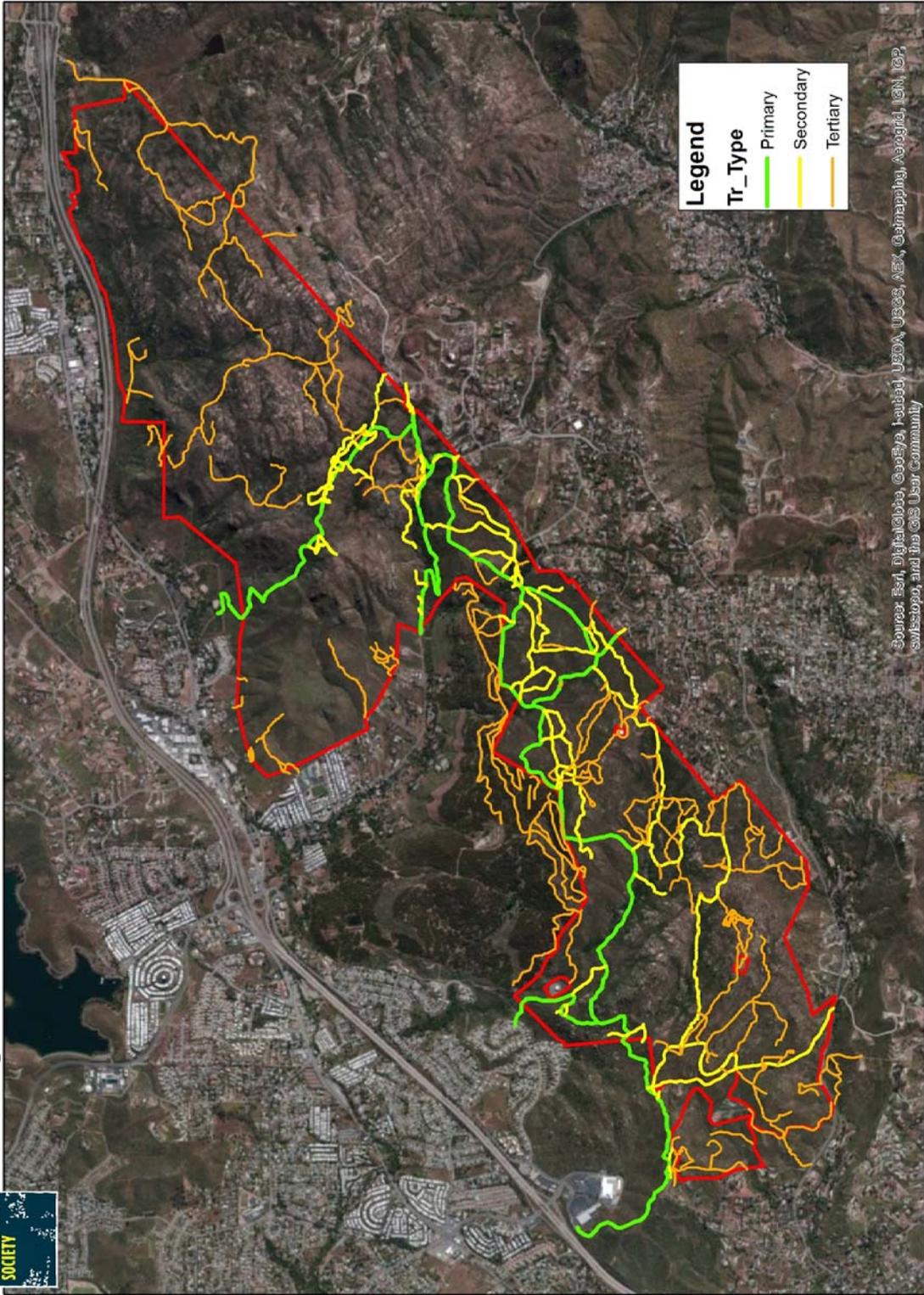
Carmel Mountain Trails



0 0.25 0.5 0.75 1 Mile

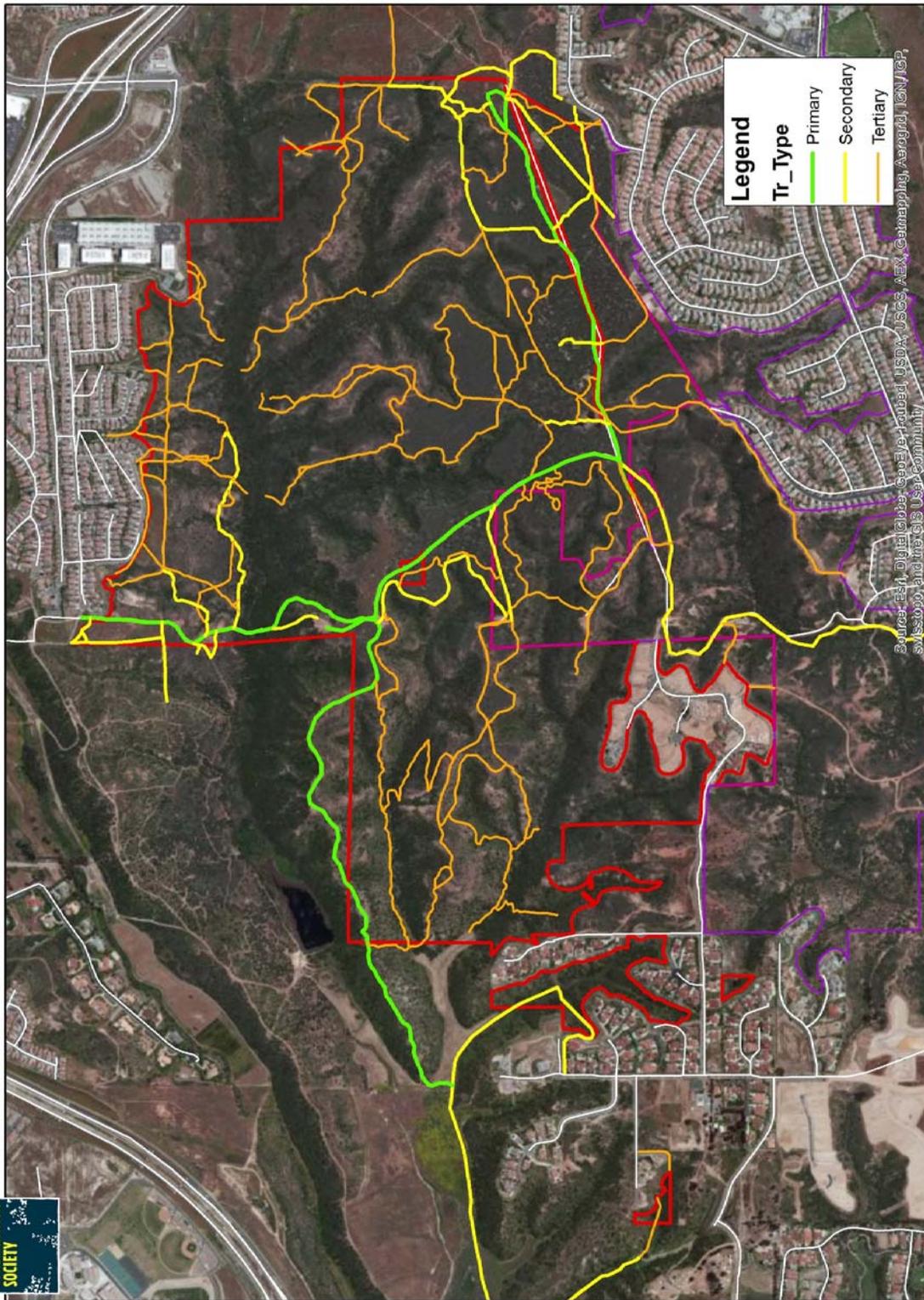


Crestridge Trails



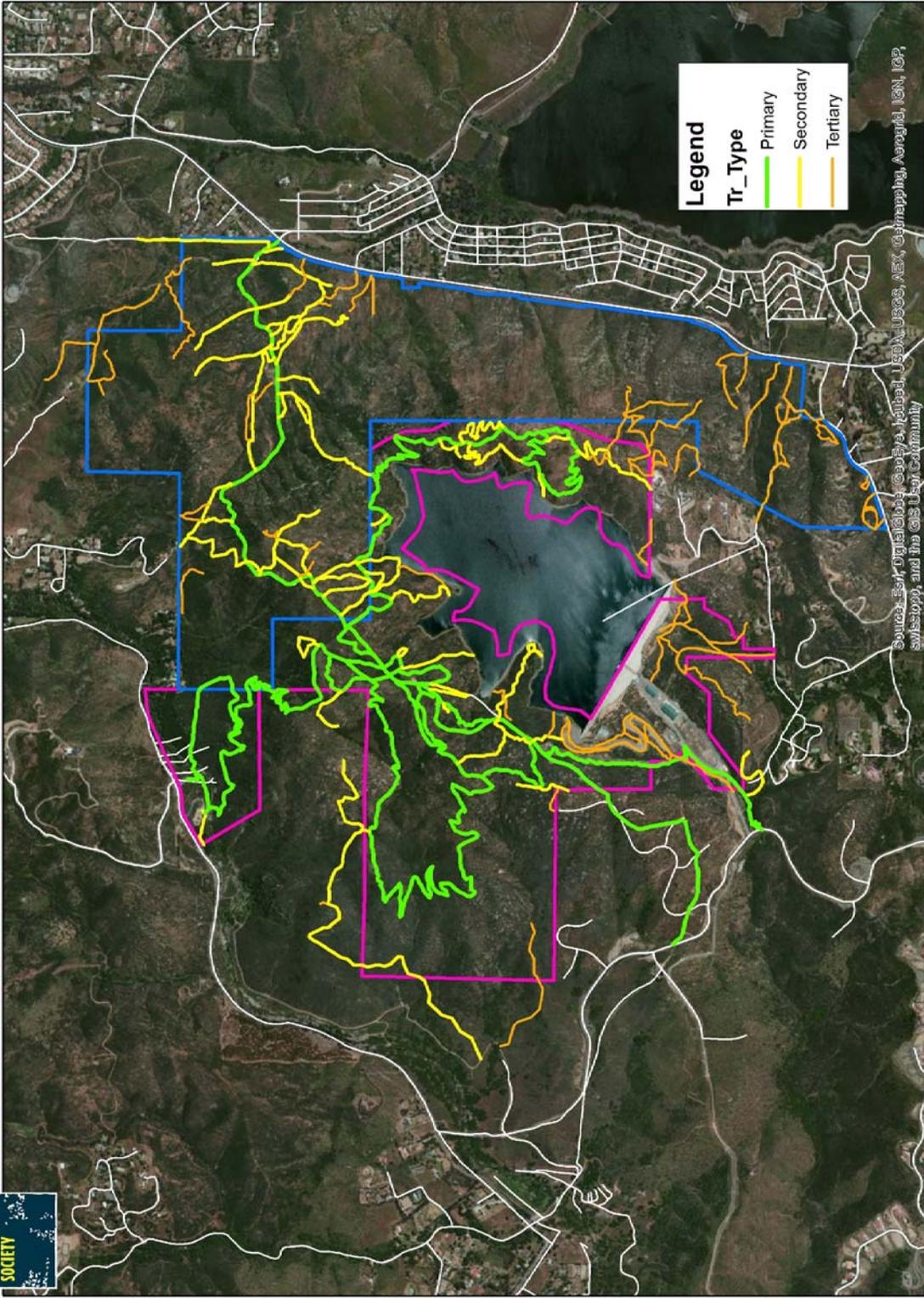


Del Mar Mesa Trails



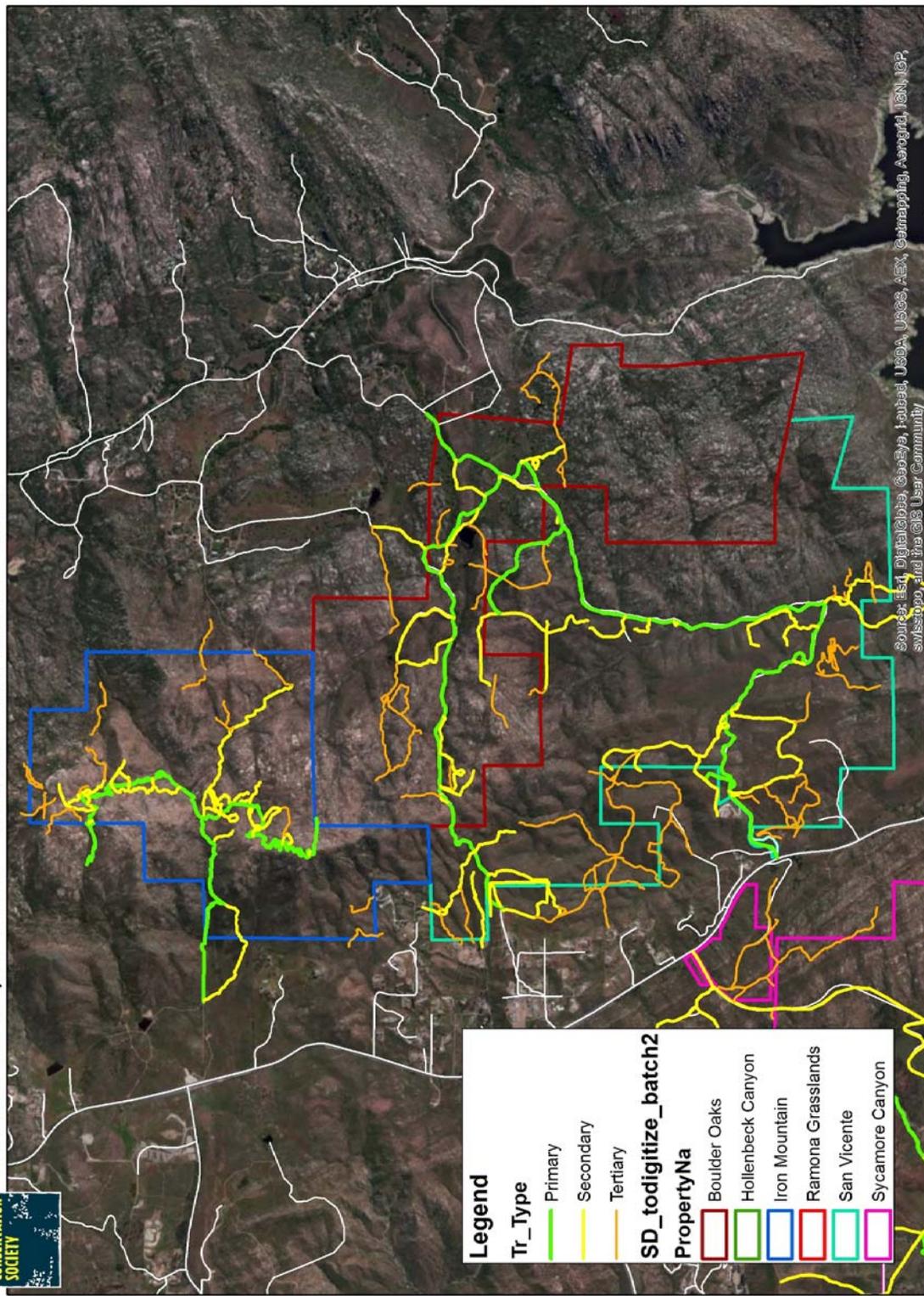


Elfin Forest and Del Dios Highlands Trails





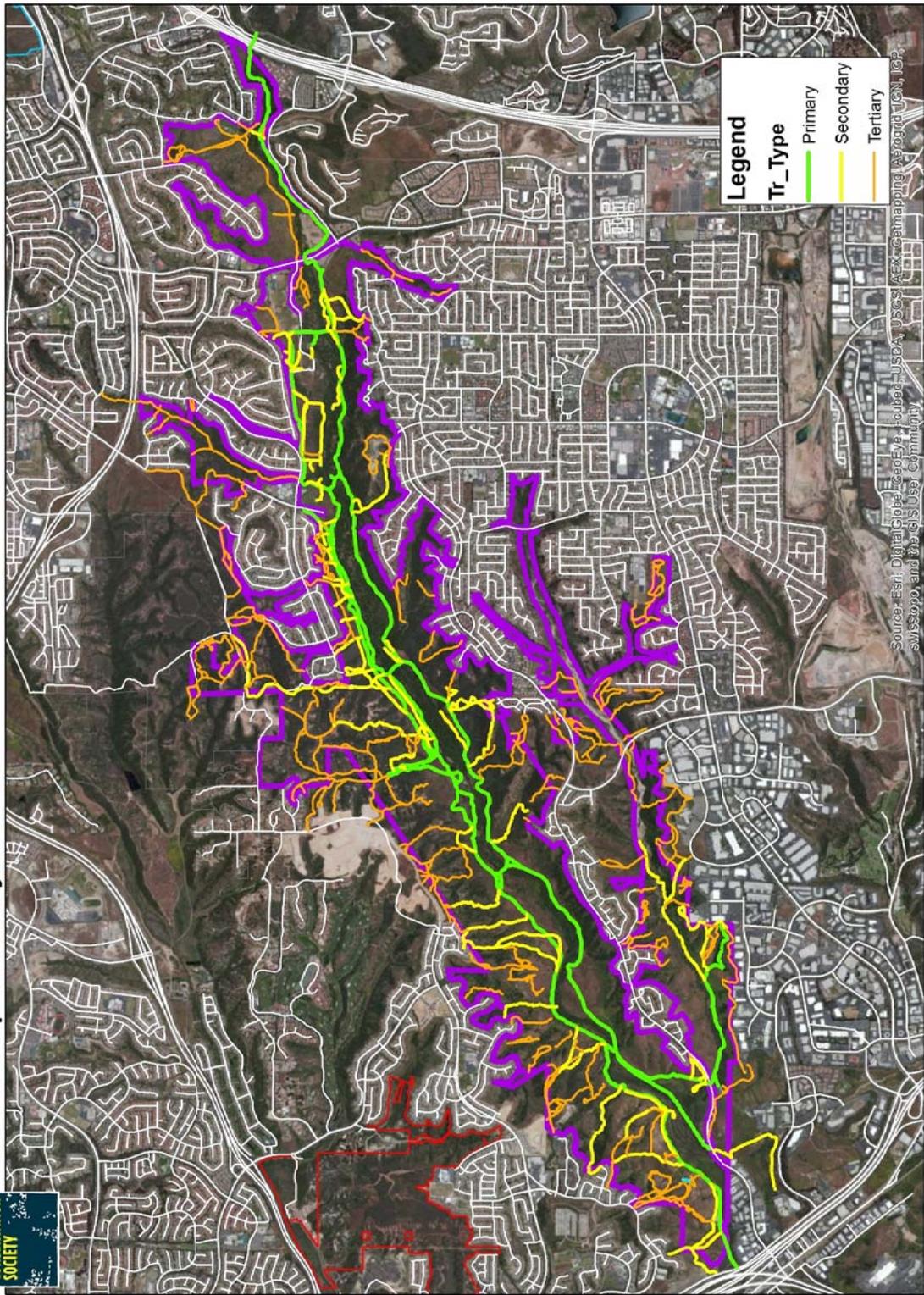
Iron Mountain, Boulder Oaks and San Vicente Trails



Source: Esri, DigitalGlobe, GeoEye, iSatellite, USDA, USGS, AeroGRID, IGN, IGP, swisstopo, and the GIS User Community

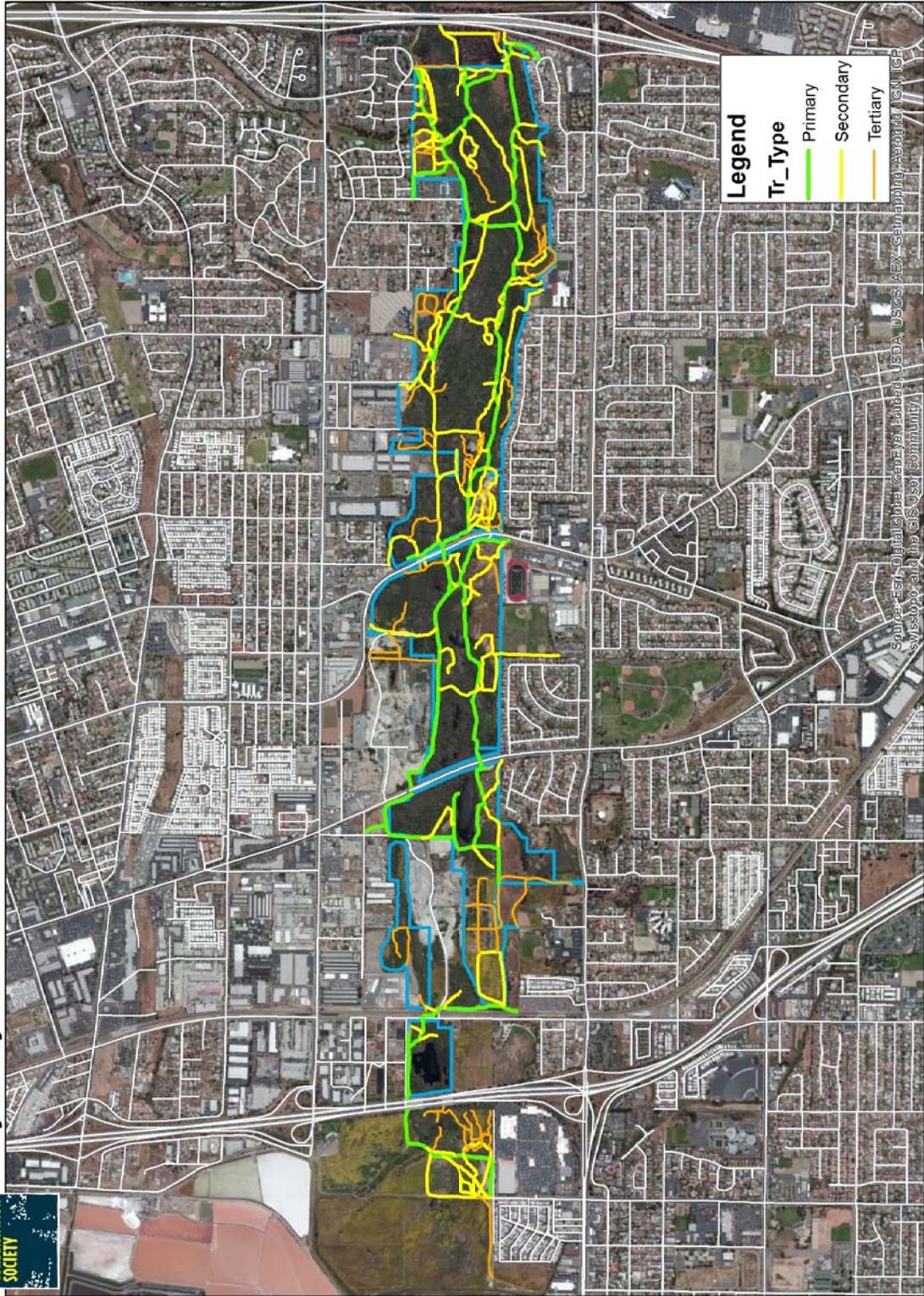


Los Penasquitos Canyon Trails



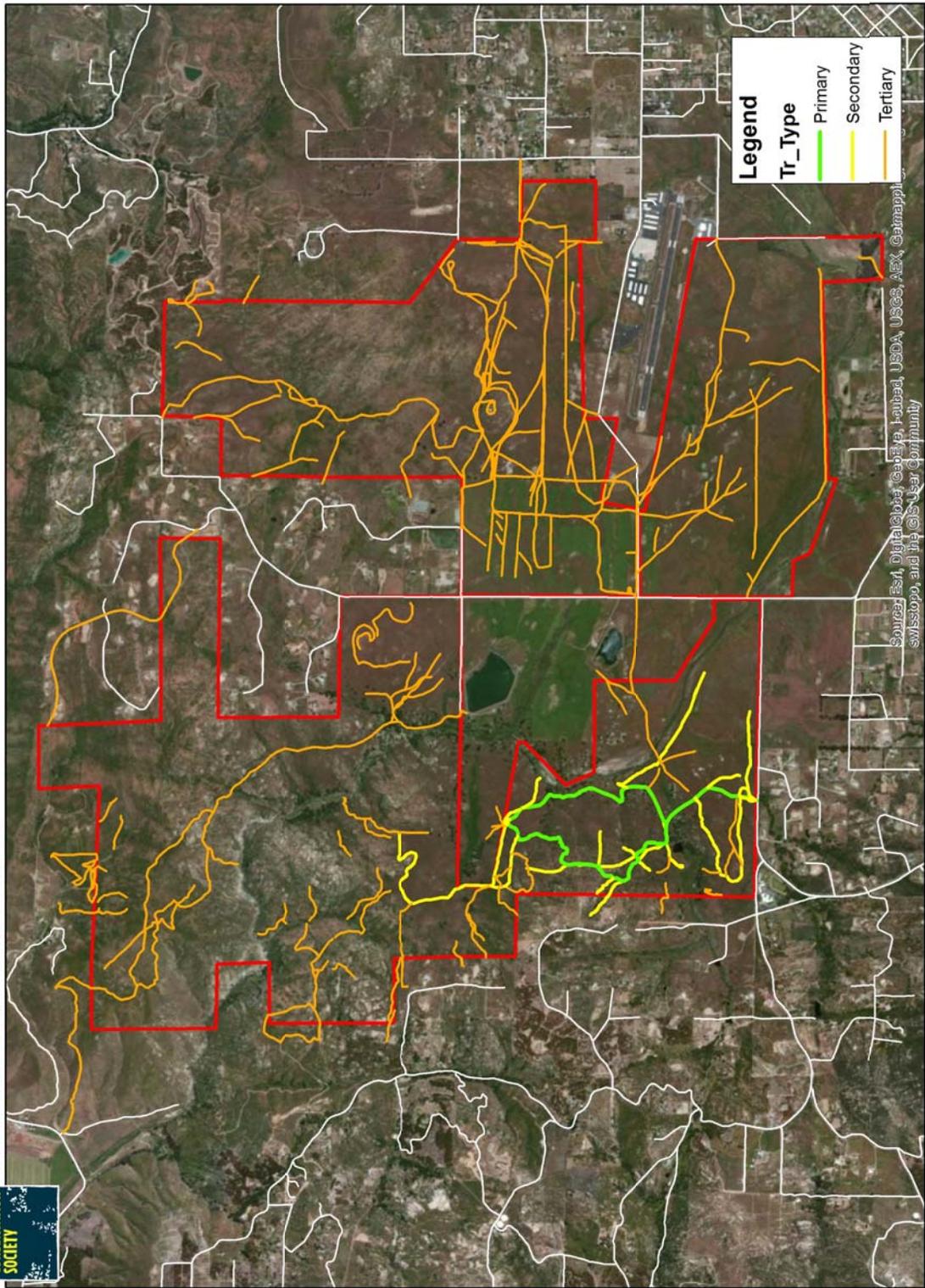


Otay Valley Trails



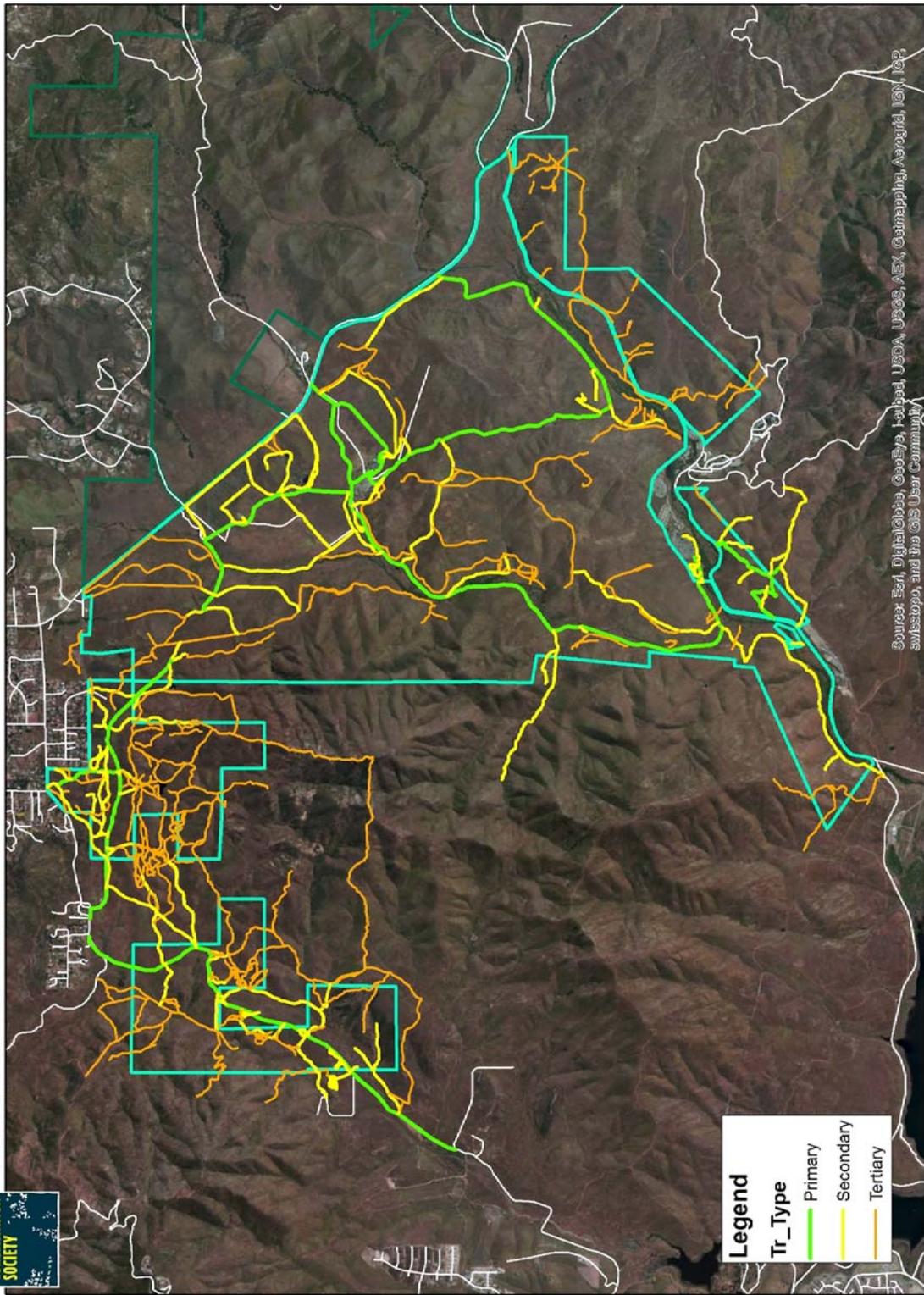


Ramona Grasslands Trails



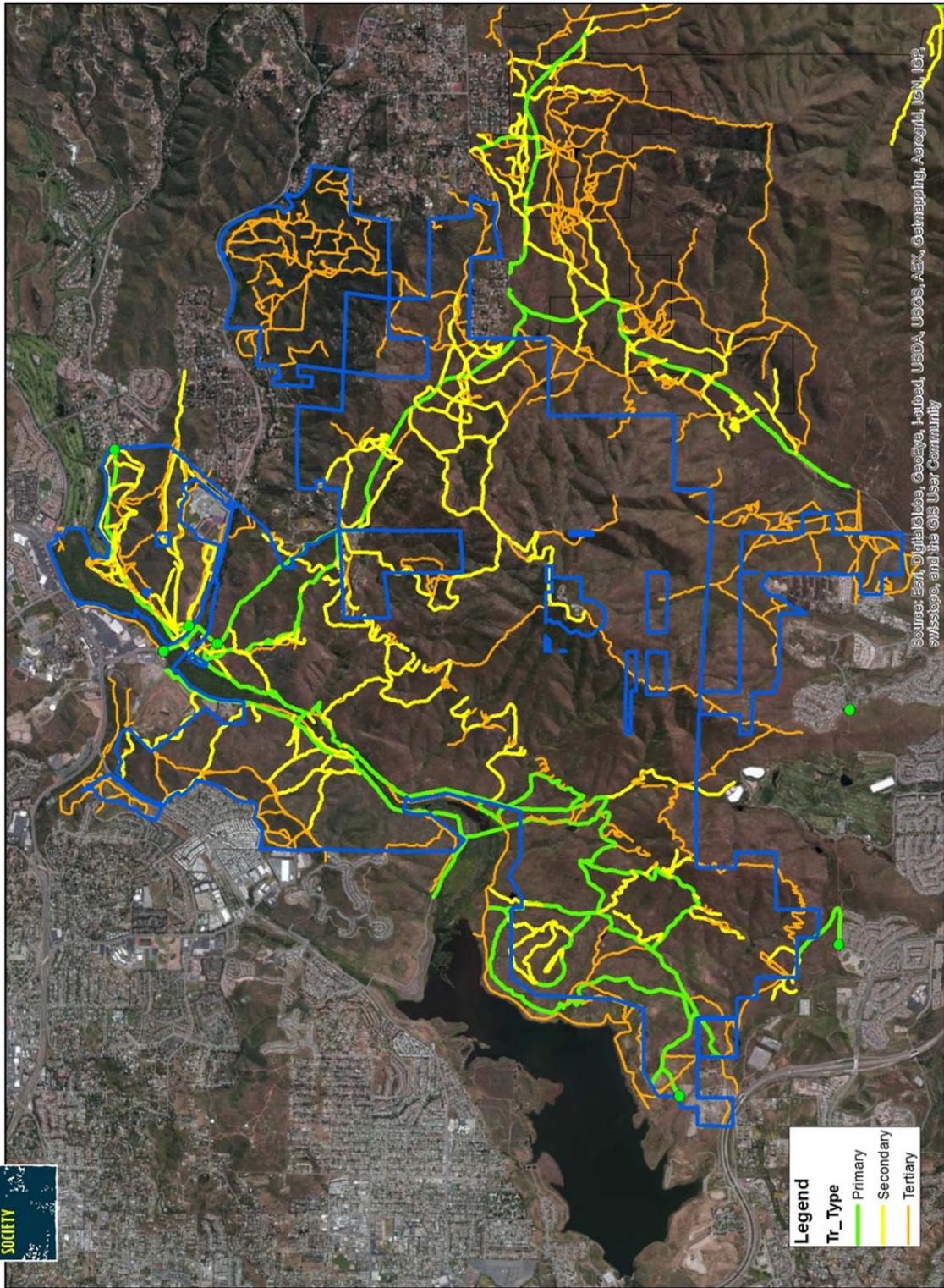


Rancho Jamul Trails





National Wildlife Refuge Trails

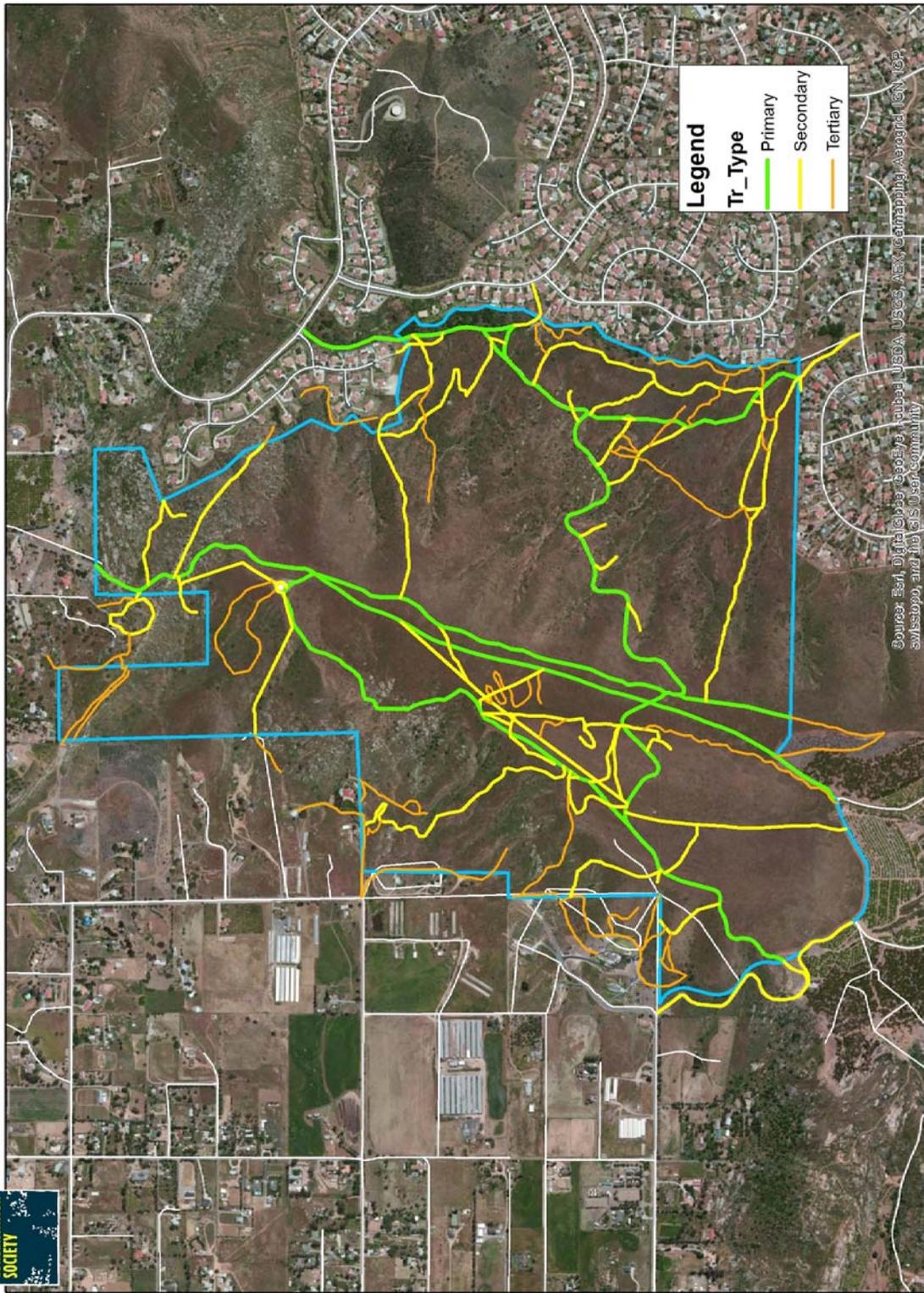


Legend	
Tr_Type	
Primary	Green line
Secondary	Yellow line
Tertiary	Orange line



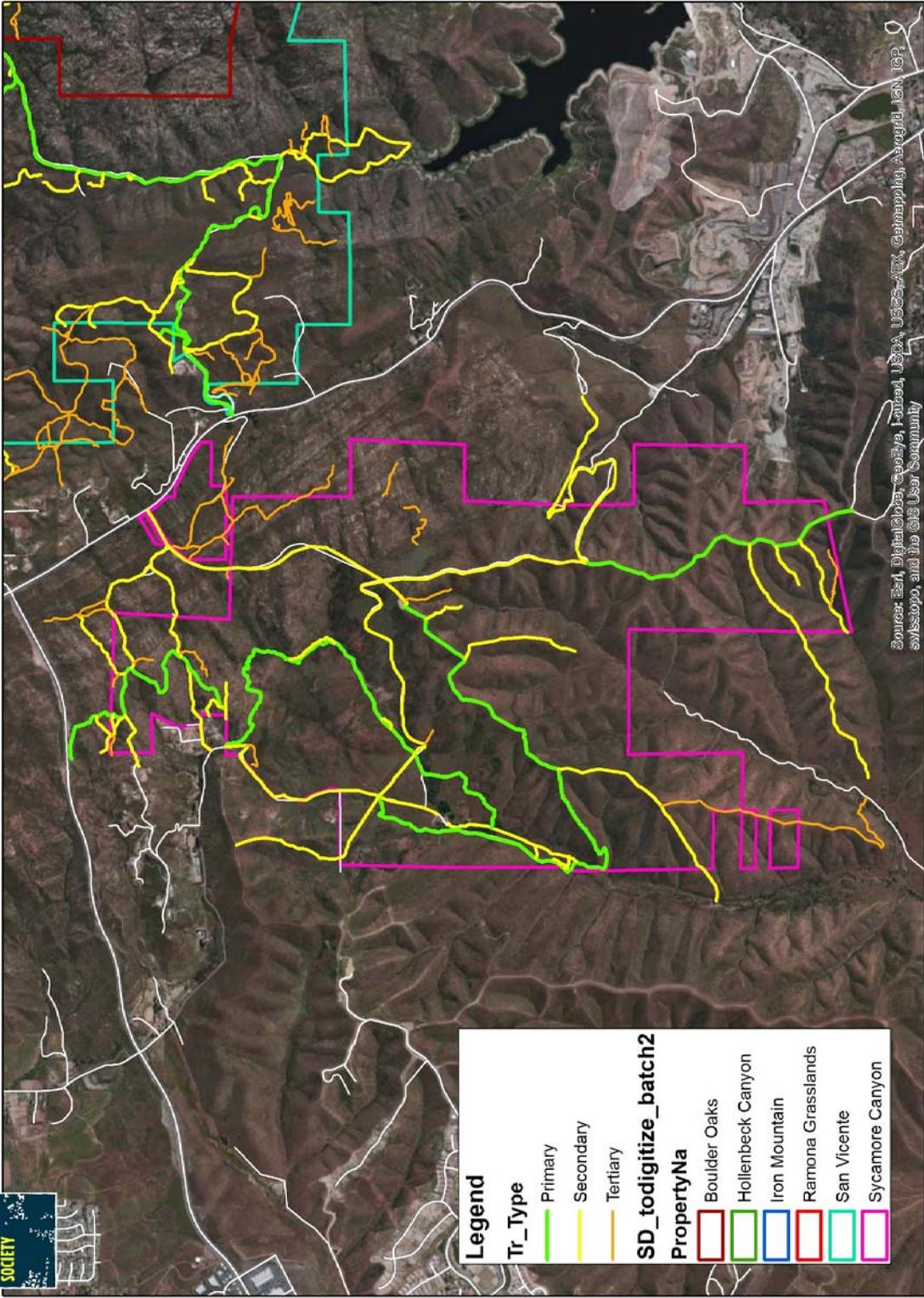


Simon Preserve Trails





Sycamore Canyon Trails



Legend	
Tr_Type	Primary
	Secondary
	Tertiary
SD_todigitize_batch2	
PropertyNa	Boulder Oaks
	Hollenbeck Canyon
	Iron Mountain
	Ramona Grasslands
	San Vicente
	Sycamore Canyon

Source: Esri, DigitalGlobe, GeoEye, Earthstar, USGS, AeroGRID, IGN, IGP, swisstopo, and the GIS User Community



Appendix 4. List of species monitoring data collected from SDMMMP.

Dataset	Species	Type	Locations/extent	Years	Resolution
MtLion	Mountain lion	GPS locations from radio collars	Throughout county, east of most sites	2012	points
PHCO	Coast horned lizard	Species distribution model	Throughout county	n/a	100 m pixels
CAGN	California gnatcatcher	Presence/absence	Throughout county	2004, 2007, 2009	points
Pitfall	Many	Presence	Hollenbeck Canyon, Mission Trails, San Diego NWR, Carmel Mountain, Del Mar Mesa, Crestridge	1995-2012	points
CACW	Cactus wren	Presence/absence	Throughout county	2009, 2011	points
BirdAtlas	Many bird species	Presence	Throughout county	1997-2002	grid cells (3 mi x 3 mi)
GoldEag	Golden eagle	Known nesting and foraging areas	Throughout county, on eastern side of study area	2010	points and polygons
Reports	various	Baseline biodiversity survey reports	Del Dios Highlands, Boulder Oaks, Crestridge, Barnett Ranch, Ramona Grasslands, Sycamore Canyon, Simon Preserve	various	various

Appendix 5. State Wildlife Grant (SWG) proposal submitted in March 2014.

PROJECT NAME

Effects of Human Use of NCCP Reserves on Reptile and Mammal Species in San Diego County, California. Species that would benefit from completion of this project include, at minimum, the following Covered Species in the San Diego Multiple Species Conservation Program (MSCP) and/or CDFW Species of Special Concern (SSC): orange-throated whiptail (*Aspidoscelis hyperythrus beldingi*), San Diego horned lizard (*Phrynosoma coronatum*), two-striped garter snake (*Thamnophis hammondi*), mountain lion (*Puma concolor*), mule deer (*Odocoileus hemonius*), and black-tailed jackrabbit (*Lepus californicus bennettii*).

FEDERAL FUNDS REQUESTED

\$309,248 over two years (partial funding could be used to fund Year 1 or a subset of tasks).

NEED

Protected areas are commonly established with a dual mandate to provide public access for outdoor recreation, education, and other human activities while also protecting plant and animal species, their habitats, and the ecological processes upon which they depend. Outdoor recreation has many human health (Frumkin 2001) and economic benefits (Goodwin 1996); it also influences people's political and financial support for land and wildlife conservation (Zaradic et al. 2009). Although the negative effects of extractive and consumptive land uses within protected areas are well known (e.g., Liu et al. 2001), outdoor recreation is often assumed to be compatible with species protection (Reed & Merenlender 2008). However, a growing body of research demonstrates that outdoor recreation can negatively impact plant and animal communities (Liddle 1997). Recreation is the second-leading cause of endangerment to species occurring on U.S. federal lands (Losos et al. 1995), and of all U.S. states, California has the greatest number of listed species threatened by recreation (Czech et al. 2000). Recreation activity has been linked to declines in wildlife species occupancy, abundance and density (Banks & Bryant 2007, Reed & Merenlender 2008), changes in spatial or temporal habitat use (George & Crooks 2006, Cardoni et al. 2008), increased physiological stress (Arlettaz et al. 2007), reduced reproductive success (Finney et al. 2005), and behavioral effects such as increased vigilance and flight (Taylor & Knight 2003).

Participation in outdoor recreation and rates of visitation to protected areas are increasing rapidly in the U.S. (Cordell 2008) and around the world (Balmford et al. 2008). Land and wildlife managers are seeking solutions to balance the benefits of outdoor recreation for human communities with its potentially negative effects on species and ecosystems (Hadwen et al. 2007). Despite growing evidence of recreation impacts, few studies have made comparisons between protected areas that do and do not permit recreation (Reed & Merenlender 2008), examined recreational impacts among multiple sites within a reserve network (Forrest & St. Clair 2006), or compared the responses of multiple species in a community (Blumstein et al. 2005). Landscape-level studies of the effects of recreation on wildlife communities are needed in order to understand which species are most likely to be sensitive to human recreation and in which locations those species are exposed to a level of human use that exceeds their threshold of disturbance, with potentially negative population- and community-level consequences.

PROJECT HISTORY

In 2012, a Local Assistance Grant (#P1182112) was awarded by California Department of Fish and Wildlife (CDFW) for the first phase of a collaborative project among the Wildlife Conservation Society (WCS), Colorado State University (CSU), and University of California, Berkeley (UCB) to develop a research plan for assessing the possible effects of human recreation on wildlife populations in the San Diego County Natural Community Conservation Plan (NCCP) reserve system. Specific objectives of this applied research project were to: (1) Develop a research design in collaboration with local researchers and managers for studying the effects of recreation on wildlife species to inform adaptive management decisions; and (2) Test methods for monitoring levels of recreational disturbance and complete a pilot study, which will be used to revise and improve the research design and maximize our ability to detect the possible effects of recreation on multiple species. The agreement for this planning phase ends in April 2014. Accomplishments to date include implementing a systematic review of studies examining the impacts of recreation on wildlife; acquiring and refining a geographic information system (GIS) database to facilitate field site selection and spatial analysis; creating a database of official and unofficial recreational trails digitized from aerial imagery; designing and conducting an expert opinion survey to

assess relative levels of visitation to 35 NCCP reserves; implementing a pilot field study to test methods for monitoring recreation visitation and provide a quantitative estimate of overall visitation levels at 18 reserves (Fig. 1); and completing a detailed survey of variation in visitation patterns within the interior of one reserve (Reed et al. 2013).

This planning phase has yielded important information regarding the likely (or unknown) sensitivity of wildlife species to recreation and their relative exposure to recreation activity in NCCP reserves; thus, it provides a basis for selecting which wildlife species to study and which reserves to monitor in the next phase. It also generated recommendations for selecting survey techniques and designing sampling strategies for monitoring recreation activity. Additional funding is now needed to implement a well-designed study that integrates species monitoring with recreation monitoring to systematically assess recreation's direct and indirect effects on sensitive wildlife species, to improve our understanding of the trade-offs inherent in multiple-use management of reserves, and to ensure that NCCP reserves are providing the required levels of protection and achieving the goals of the NCCP program.

LINKAGE TO CALIFORNIA STATE WILDLIFE ACTION PLAN

Wildlife provides significant economic benefits to the State of California through recreation, tourism, and commercial harvest. Many of the places where wildlife thrive are the same as those valued for recreation and other human activities, and accompanying growth and development is an increasing demand by the public for recreational access to public land, waterways, and ocean resources. In the 2005 California State Wildlife Action Plan (SWAP), *recreational pressures* are major wildlife stressors identified for the South Coast, Central Coast, and Sierra Nevada regions (p. 29), and *intensity of human recreation use* is included as a variable that could be used to monitor landscape-level issues that affect multiple natural community assemblages or otherwise cross-cutting issues (p. 50). In the South Coast region in particular, with nearly 20 million people living within driving distance of the region's national forests and other public lands, recreational access and its subsequent effects are a major concern. Concentrated recreational use of streams and riparian areas is particularly troublesome. Not only off-road vehicles, but hikers, picnickers, and equestrians in large numbers can damage these systems, reducing vegetative cover and disturbing sensitive species. Species identified as particularly vulnerable include herpetofauna such as the two-striped garter snake (*Thamnophis hammondi*), mountain yellow-legged frog (*Rana muscosa*), and arroyo toad (*Anaxyrus californicus*) (p. 180; Stephenson & Calcarone 1999). To conserve habitat and species in the South Coast Region's rapidly urbanizing areas, the primary conservation action recommended by the SWAP is for wildlife agencies and local governments to work to improve the development and implementation of NCCPs (p. 181).

EXPECTED RESULTS OR BENEFITS

- This project will assess the degree to which human use of NCCP reserves may be affecting Covered and sensitive species while also providing recreation opportunities and experiences for San Diego residents.
- By implementing our study along a gradient of human use intensity, our project will assess alternative use-impact relationships between human activity and wildlife responses (Monz et al. 2013) and identify possible thresholds of the level, type, timing, and spatial extent of human activities that lead to wildlife impacts.
- A community-level survey approach will allow us to determine which target and non-target reptile and mammal species are most sensitive to disturbance by human use, and in which locations those species are exposed to a level of human activity that exceeds their threshold of disturbance.
- Pairing the observational study with a before-after control-impact (BACI) experiment will generate additional evidence regarding causal links between human activity and wildlife responses, relative to other known drivers of species distributions, and it will also provide an explicit test of management alternatives of opening, restricting, or closing NCCP reserves to public access.
- Results of this project will inform ongoing management of human activity in NCCP reserves and support future decisions regarding public access and designated use of reserve lands statewide.

MULTI-SPECIES BENEFIT

This study will focus on two groups of species of local conservation concern: reptiles and mammals. Reptile communities in San Diego County include three species that are Covered Species in the San Diego MSCP and/or are listed as SSC by CDFW: orange-throated whiptail (*Aspidoscelis hyperythrus beldingi*), San Diego horned lizard (*Phrynosoma coronatum*), and two-striped garter snake (*Thamnophis*

hammondii). However, the specific focal reptile species for this study will be selected in collaboration with the Wildlife Agencies, USGS, and other researchers. Herpetofauna are among the least well-studied groups of taxa in response to recreation. Fewer than 6% of published studies of recreation impacts on wildlife focus on reptiles or amphibians, but they are the taxa most frequently impacted by recreation activity, with 63% of studies finding statistically significant effects (C. Larson, unpublished data). Reptiles are likely to be vulnerable to disturbance because their habitats are also desirable destinations for humans, they are targets of illegal collectors (Buhlmann & Tuberville 1998), human activity is a source of direct mortality along roads and trails (Rochester et al. 2001), and because they are sensitive to displacement by competitor and predator species adapted to human activity (Spinks et al. 2003). Prior studies have shown that recreation can impact the survival (Iverson et al. 2006), population size (Garber & Burger 1995), and physiological condition (Amo et al. 2006) of reptiles and amphibians. However, to date no study has been conducted of the effects of recreation on reptiles or amphibians at the community- or landscape-level.

The second group of focal taxa for this study will be mid-sized to large mammals. The response of mid-sized to large mammal species to recreation has been examined in other California ecosystems, with species such as bobcats (*Felis rufus*) and coyotes (*Canis latrans*) exhibiting decreased abundance or temporal displacement in response to human activity (George & Crooks 2006, Reed & Merenlender 2008). One prior study in San Diego County demonstrated that mountain lions (*Puma concolor*) were negatively associated with recreational biking, but did not include any reserves without public access or measure relative levels of visitation (Markovchick-Nicholls et al. 2008). Our proposed surveys of reserve visitors using remotely-triggered cameras will also produce detections of other mammal species covered by the MSCP, such as mountain lion, mule deer (*Odocoileus hemionus*), and black-tailed jackrabbit (*Lepus californicus bennettii*). Additionally, community-level surveys will help to identify non-target species that may also be sensitive to disturbance (e.g., gray fox) and reveal overall changes in community composition related to human activity that may indirectly affect the target species.

OBJECTIVES

- 1) Validate a landscape-level spatial model of the intensity of human use among NCCP reserves;
- 2) Develop and test a citizen science approach for collection of fine-scale human use patterns within a reserve;
- 3) Implement an observational study in a gradient design to relate spatio-temporal variation in human activity to the occurrence and relative abundance of reptiles and mammals; and
- 4) Conduct a before-after control-impact (BACI) experiment to monitor the response of reptile and mammal species to changes in human activity patterns.

MAJOR TASKS

- 1) Validate landscape-level model of human use intensity
 - a. Monitor spatio-temporal variation in human use intensity by activity type within and among NCCP reserves;
 - b. Compare model predictions to actual visitation levels among NCCP reserves, and refine model if necessary.
- 2) Develop and test a citizen science approach for collection of human activity data
 - a. Apply a participatory smartphone application (“app”) for visitors to submit data regarding their activity and route within a reserve;
 - b. Compare data collected with app to monitoring data collected in Task 1, and develop a model of human use intensity by trail segment within NCCP reserves.
- 3) Relate variation in human activity to focal species occurrence and abundance
 - a. Assess the occurrence, community composition, and relative abundance of focal reptile and mammal species along a gradient of human use intensity within multiple NCCP reserves;
 - b. Investigate the relationship between human activity and the occurrence and relative abundance of sensitive focal species, while accounting for habitat characteristics, community composition, and other factors influencing species distributions.
- 4) Relate the response of species communities to changes in human activity
 - a. Monitor changes in human activity before and after expansion of a trail network at one NCCP reserve and closure of unofficial trails at a second NCCP reserve;
 - b. Assess the occurrence, community composition, and relative abundance of reptile and mammal species before and after planned changes in the trail network at the two sites;

- c. Investigate the relationship between changes in human activity and changes in the occurrence, community composition, and relative abundance of the focal species.

APPROACH

Sampling design

Study sites and sampling points will be selected to represent variation in the intensity of human use within and among NCCP reserves. For this proposal, we define *human use* to include outdoor recreation as well as the many other human activities that occur within NCCP reserves (e.g., commuting, management, illegal activities). First, we will select 12 study sites (>100 ha) along a gradient of overall levels and types of human use of NCCP reserves, as predicted by a landscape-level spatial model of human use intensity. This model applies likely predictors of the level of visitation to a reserve, including its accessibility, landscape context, site amenities, and other factors. We will develop our model using data on human activity collected during the pilot study in 2013 (Fig. 1), and we will validate its predictions using data collected during the proposed study. Study sites will include reserves that are officially closed to public access, because we assume that they will have the lowest levels of human use (but may still experience some unofficial use). Two additional study sites will be selected for the BACI experiment: one NCCP reserve in which the trail network is planned to be expanded and a second NCCP reserve at which unofficial trails are planned to be closed.

Within the each of the 14 study sites, we will locate eight sampling points to survey for human activity and focal species. Our pilot study indicated that visitation levels are highly variable among trails within a single reserve (range: 2.5-45.2 visitors per day) but that factors influencing that variation (e.g., trailheads, accessibility, site amenities) are likely to vary among sites; thus, sampling points will be selected in a spatially-balanced random design throughout the interior of each site (Theobald et al. 2007). Unofficial or user-created trails comprise a mean of 41% of the trail networks in 19 reserves mapped for the pilot study (range: 8-85%) and likely receive substantial human use; thus, sampling points will be located along both official and unofficial trails. If trail networks within a selected reserve are not available as a GIS data layer or were not previously mapped during the pilot study (Reed et al. 2013), we will create spatial data via heads-up digitizing of trail features from aerial photography. The spatially-balanced survey design will also be weighted to select sampling point locations within land cover types that are known habitats of the focal species.

Monitoring human activity

The objective of monitoring human activity is to collect a continuous measure of human use intensity among trail segments, while accounting for variation among activity types and seasons. We will apply two methods to collect data on human activity: a citizen science approach using a participatory smartphone application (“app”) and passive monitoring using remotely-triggered cameras. The app will make use of the GPS function of smartphones and allow users to record their activity and route through a reserve. To implement the app, we will seek to partner with an existing developer of mobile fitness applications (e.g., MapMyRun) and conduct an outreach program to encourage reserve visitors to share their route and associated information with the project via the social networking feature of the app.

We will test the effectiveness of the citizen science approach by comparing it to data collected by passive monitoring using remotely-triggered cameras. In our pilot study, we found that remotely-triggered cameras were the most efficient and cost-effective technique currently available for counting visitors to protected areas. Remotely-triggered cameras function similarly to automated trail counters, employing passive infrared light beams to detect passing objects and record the date and time. Benefits of this sampling method include collecting a continuous, automated record of visitation by type of activity and direction of travel. Remotely-triggered cameras will be installed at each sampling point, set to record continuously day and night for a period of 4 weeks, and checked every 2 weeks. Sampling periods will be repeated four times per year to capture seasonal variability in type and intensity of human use. Visitor counts from remotely-triggered cameras will be calibrated with timed visual observations, to estimate errors and convert raw data into reliable visitation estimates (Pettebone et al. 2010). The monitoring data will be integrated into spatio-temporal models of human use intensity among trail segments, based on landscape features, accessibility, and site amenities.

Reptile and mammal surveys

We will survey for reptile communities using two complementary non-invasive techniques at the sampling point locations identified above. First, we will conduct visual surveys to document incidental

mortalities of reptiles and amphibians along trails (Rochester et al. 2001). Specifically, a single observer will walk slowly along a 250m transect centered at the sampling point, following standard techniques to document the species and point location of all reptiles detected (USGS 2006). Transect surveys will be repeated twice weekly for two weeks, and sampling periods will be repeated four times per year for one year. We will also explore opportunities to augment surveys of incidental mortalities by incorporating a field for visual observations into the participatory smartphone app. Second, we will conduct artificial cover surveys to detect reptile species. Although artificial cover surveys do not produce as many detections of herpetofauna as pitfall traps (Case & Fisher 2001), they are relatively effective for sampling lizard community composition and abundance (Ryan et al. 2002). They are also less expensive and labor-intensive to install and maintain than drift fences, allowing us to survey a large number of locations across a gradient of human activity within and among reserves. An array of 10 coverboards will be installed at each sampling point for a period of two weeks and checked twice weekly. Artificial cover surveys will be repeated four times per year for one year.

Remotely-triggered cameras, which will be used to monitor human activity, are also an effective non-invasive method for monitoring mammal occupancy and activity patterns (Kays & Slauson 2008) and have been used previously to investigate the response of mammal species to recreation activity along trails (George & Crooks 2006). As described above, one remotely-triggered camera will be installed at each sampling point, set to record continuously day and night for a period of 4 weeks, and checked every 2 weeks. To reduce possible sources of bias, camera stations will not be baited. Sampling periods will be repeated four times per year for one year. Photos will be identified to species, and we will pool detections of species for the duration of a week to represent one survey replicate for each sampling period.

Should this project be funded, the proposed survey methods and focal species will be reviewed jointly by the researchers, wildlife agencies, and SDMMMP, and we will take into account opportunities to enhance our data collection through collaboration with other ongoing research and monitoring activities.

Statistical analysis

We will apply several quantitative measures to summarize human activity. Visitor counts will be defined as the number of single-person visits made to a reserve or trail in a day (Watson et al. 2000). Temporal variation in human activity will be defined as variation in visitor counts among hours of the day and days of the week. Intensity of human use will be defined as mean total visitor counts adjusted for reserve area or trail length. We will examine relationships between human activity and detection of the focal species to assess: (1) the effect of human use relative to other known drivers of species distributions (e.g., habitat fragmentation, invasive species); and (2) the relative importance of individual human activities (e.g., hiking, mountain biking) and local habitat characteristics on the occurrence, community composition, and relative abundance of reptile and mammal species in NCCP reserves. We will apply occupancy modeling (MacKenzie et al. 2006) and regression analyses within a model selection framework (Burnham & Anderson 2001) to examine alternative possible use-impact relationships between human activity and wildlife responses (Monz et al. 2013).

DELIVERABLES

- A validated model of human use intensity for up to 89 NCCP reserves;
- Detailed monitoring of human use by activity, among trails, and over time within 12 NCCP reserves;
- Data on the occurrence, community composition, and relative abundance of up to six focal species which can be contributed to the San Diego multi-taxa database;
- A comprehensive report describing the project methods, results, and implications;
- Presentations to wildlife agencies (CDFW and USFWS), reserve managers, and other interested parties regarding the project results and implications for species monitoring and management; and
- Peer-reviewed journal articles communicating results to the broader scientific community.

LOCATION

This research will be conducted within NCCP reserves in San Diego County (Fig. 1). The current NCCP reserve system in San Diego County includes more than 200,000 acres of protected lands, which are monitored and managed by multiple jurisdictions for the benefit of 103 plant and animal species. We will select study sites to represent a variety of managing agencies and landscape contexts, to ensure that the results of this research are relevant to inform adaptive management decisions regarding public access and human activity across the NCCP reserve system. The results will also be applicable to other reserve systems being established in other regions of the State.

ESTIMATED COST

Please refer to attached budget worksheet. The two-year project optimally distributes resources. However, if only partial funding is available, it would be possible to conduct only Year 1 tasks (Year 1 cost is \$166,910). Alternatively, separate tasks could be funded over the two years, with State (NCCP Local Assistance Grant) and local San Diego funding (Transnet) sought to fund remaining tasks.

TAKING

All of the survey methods proposed for this project are non-invasive. We do not anticipate that conducting this project will result in 'take,' either purposeful or inadvertent, of individuals of the species named in the proposal or of any other federally-listed or federal candidate species.

LETTERS OF SUPPORT (attached) FROM:

CDFW Region 5
State Wildlife Action Plan

CONTACT INFORMATION

CDFW Project Manager:

Dr. Brenda Johnson
Environmental Program Manager
Landscape Conservation Planning Program
Habitat Conservation Planning Branch
Telephone: 916-653-0835
Email: brenda.johnson@wildlife.ca.gov

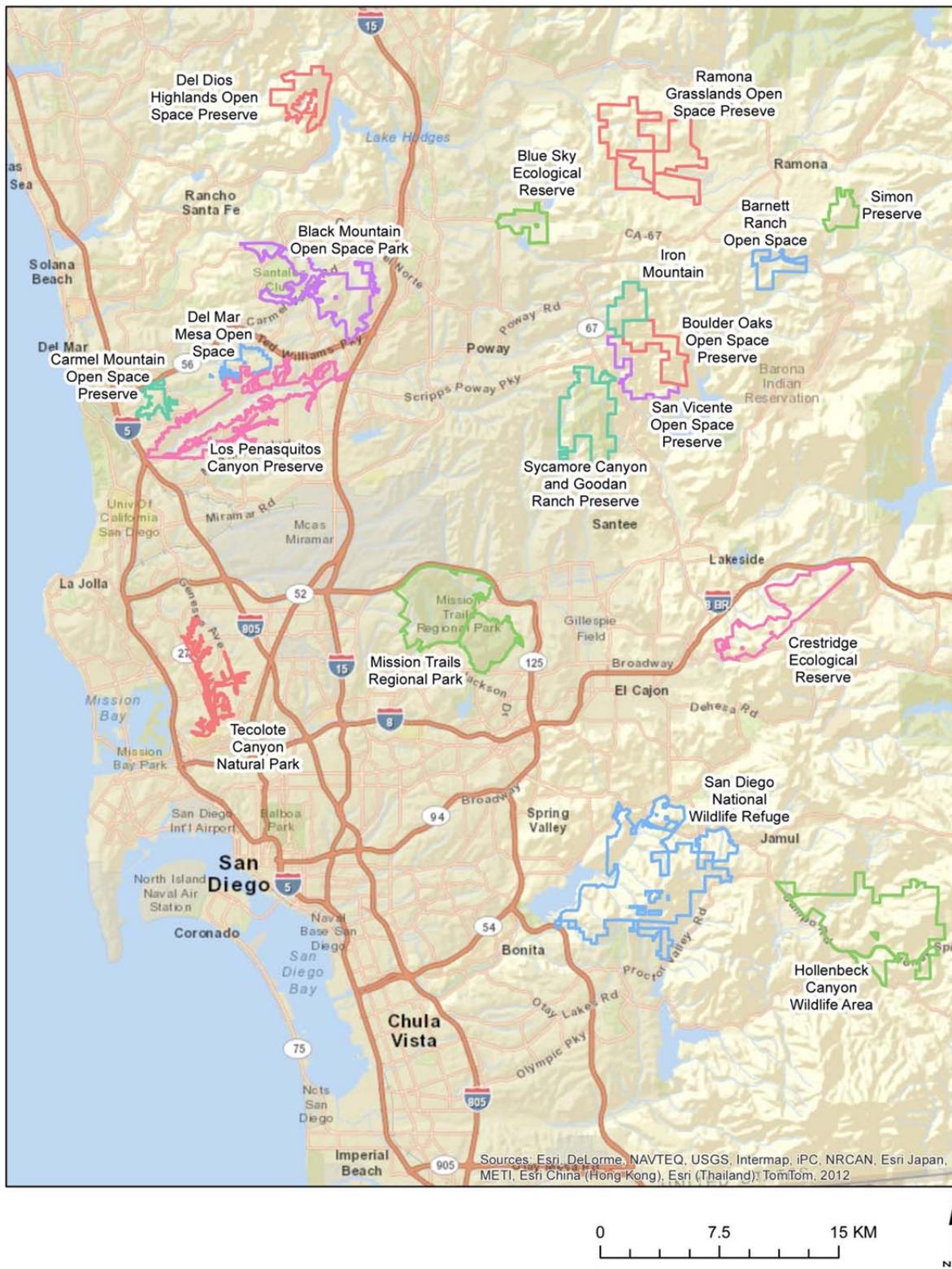


Figure 1. NCCP reserves included in the pilot study of human activity in 2013. The monitoring data will be used to develop a landscape-level spatial model of human use intensity and applied to select study sites for the proposed project, which will represent a variety of managing agencies and landscape contexts of NCCP reserves in San Diego County.

LITERATURE CITED

- Amo, L., P. Lopez and J. Martin. 2006. Nature-based tourism as a form of predation risk affects body condition and health state of *Podarcis muralis* lizards. *Biological Conservation* 131:402-409.
- Arlettaz, R., P. Patthey, M. Baltic, T. Leu, M. Schaub, R. Palme, and S. Jenni-Eiermann. 2007. Spreading free-riding snow sports represent a novel serious threat for wildlife. *Proceedings of the Royal Society B* 274:1219–1224.
- Balmford, A., J. Beresford, J. Green, R. Naidoo, M. Walpole and A. Manica. 2009. A global perspective on trends in nature-based tourism. *PLoS Biology* 7:e1000144.
- Banks, P. B., and J. V. Bryant. 2007. Four-legged friend or foe? Dog walking displaces native birds from natural areas. *Biology Letters* 3:611–613.
- Blumstein, D.T., E. Fernandez-Juricic, P.A. Zollner, and S.C. Garity. 2005. Interspecific variation in avian responses to human disturbance. *Journal of Applied Ecology* 42:943-953.
- Burnham, K.P., D. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach. Springer-Verlag, New York, NY.
- Cardoni, D. A., M. Favero, and J. P. Isacch. 2008. Recreational activities affecting the habitat use by birds in Pampa's wetlands, Argentina: Implications for waterbird conservation. *Biological Conservation* 141:797–806.
- Cordell, H. K. 2008. The latest on trends in nature-based outdoor recreation. *Forest History Today* (Spring 2008):4-10.
- Czech, B., P. R. Krausman and P. K. Devers. 2000. Economic associations among causes of species endangerment in the United States. *BioScience* 50:593-601.
- Finney, S., J. Pearce-Higgins and D. Yalden. 2005. The effect of recreational disturbance on an upland breeding bird, the golden plover *Pluvialis apricaria*. *Biological Conservation* 121:53–63.
- Fisher, R., D. Stokes, C. Rochester, C. Brehme, S. Hathaway and T. Case. 2008. Herpetological monitoring using a pitfall trapping design in Southern California. U.S. Geological Survey Techniques and Methods 2-A5, 44 pp.
- Forrest, A., and C.C. St. Clair. 2006. Effects of dog leash laws and habitat type on avian and small mammal communities in urban parks. *Urban Ecosystems* 9:51-66.
- Frumkin, H. 2001. Beyond toxicity: human health and the natural environment. *American Journal of Preventative Medicine* 20:234-240.
- Garber, S. D. and J. Burger. 1995. A 20-yr study documenting the relationship between turtle decline and human recreation. *Ecological Applications* 5:1151-1162.
- George, S. L. and K. R. Crooks. 2006. Recreation and large mammal activity in an urban nature reserve. *Biological Conservation* 133:107–117.
- Goodwin, H. J. 1996. In pursuit of ecotourism. *Biodiversity and Conservation* 5:277-291.
- Hadwen, W.L., W. Hill, and C.M. Pickering. 2007. Icons under threat: why monitoring visitors and their ecological impacts in protected areas matters. *Ecological Management & Restoration* 8:177-181.
- Iverson, J. B., S. J. Converse, G. R. Smith and J. M. Valiulis. 2006. Long-term trends in the demography of the Allen Cays Rock Iguana (*Cyclura cyclura inornata*): Human disturbance and density-dependent effects. *Biological Conservation* 132:300-310.
- Kays, R.W. and K.M. Slauson. 2008. Remote Cameras. Pp. 110-140 in R. A. Long, P. MacKay, W.J. Zielinski, and J.C. Ray, editors. *Noninvasive survey methods for carnivores*. Island Press, Washington, DC.
- Liddle, M. 1997. *Recreation Ecology: The Ecological Impact of Outdoor Recreation*. Chapman & Hall.
- Liu, J., M. Linderman, Z. Ouyang, L. An, J. Yang and H. Zhang. 2001. Ecological degradation in protected areas: the case of Wolong Nature Reserve for giant pandas. *Science* 292:98-101.
- Losos, E., J. Hayes, A. Phillips, D. Wilcove, and C. Alkire. 1995. Taxpayer-subsidized resource extraction harms species. *BioScience* 45:446-455.
- Mackenzie, D.I., J. D. Nicholls, J. A. Royle, K. A. Pollock, L. L. Bailey and J.E. Hines. 2006. *Occupancy estimation and modeling: inferring patterns and dynamics of species occurrence*. Elsevier, Boston, MA.
- Markovchick-Nicholls, H. M. Regan, D. H. Deutschman, A. Widyanata, B. Martin, L. Noreke and T. A. Hunt. 2008. Relationships between human disturbance and wildlife land use in urban habitat fragments. *Conservation Biology* 22:99-109.

- Monz, C. A., C. M. Pickering and W. L. Hadwen. 2013. Recent advances in recreation ecology and the implications of different relationships between recreation use and ecological impacts. *Frontiers in Ecology and the Environment* 11: 441-446.
- Pettebone, D., P. Newman, and S. R. Lawson. 2010. Estimating visitor use at attraction sites and trailheads in Yosemite National Park using automated visitor counters. *Landscape and Urban Planning* 97:229–238.
- Reed, S. E. and A. M. Merenlender. 2008. Quiet, non-consumptive recreation reduces protected area effectiveness. *Conservation Letters* 1:146-154.
- Reed, S. E., C. L. Larson, K. R. Crooks and A. M. Merenlender. 2013. Wildlife response to human recreation on NCCP reserves in San Diego County: Interim report to California Department of Fish and Wildlife. Wildlife Conservation Society, North America Program, Bozeman, MT.
- Rochester, C., S. Hathaway, C. Brown, K. Pease and R. Fisher. 2001. Herpetofaunal monitoring in MSCP region of San Diego. U.S. Geological Survey, San Diego, CA.
- Ryan, T. J., T. Philippi, Y. A. Leiden, M. E. Dorcas, T. B. Wigley and J. W. Gibbons. 2002. Monitoring herpetofauna in a managed forest landscape: effects of habitat types and census techniques. *Forest Ecology and Management* 167:83-90.
- Spinks, P. Q., G. B. Pauly, J. J. Crayon and H. B. Shaffer. 2003. Survival of the western pond turtle (*Emys marmorata*) in an urban California environment. *Biological Conservation* 113:257-267.
- Stephenson, J. R. and G. M. Calcarone. 1999. Southern California mountains and foothills assessment: habitat and species conservation issues. General Technical Report GTR-PSW-175, USDA Forest Service, Pacific Southwest Research Station, Albany, CA.
- Taylor, A. R. and R. L. Knight. 2003. Wildlife responses to recreation and associated visitor perceptions. *Ecological Applications* 13:951-963
- Theobald, D. M., D. L. Stevens, Jr., D. White, N. S. Urquhart, A. R. Olsen and J. B. Norman, 2007. Using GIS to generate spatially-balanced random survey designs for natural resource applications. *Environmental Management* 40:134-146.
- U.S. Geological Survey (USGS). 2006. USGS western pond turtle (*Emys marmorata*) visual survey protocol for the southcoast ecoregion. U.S. Geological Survey, San Diego, CA, 56 pp.
- Watson, A. E., D. N. Cole, D. L. Turner, and P. S. Reynolds. 2000. Wilderness recreation use estimation: a handbook of methods and systems. USDA Forest Service, Ogden, UT.
- Zaradic, P.A., O.R.W. Pergams, and P. Kareiva. 2009. The impact of nature experience on willingness to support conservation. *PLoS One* 4:e7367.