A COUPLED HUMAN AND NATURAL SYSTEMS APPROACH TO STUDYING RECREATION ON PUBLIC LANDS

by

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DEDICATION

To our public lands and the current and future generations who will enjoy them.

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ABSTRACT

Outdoor recreational use has increased rapidly in the western United States in recent years, which provides more people with opportunities to enjoy public lands and benefit from recreation. However, increased recreation can lead to negative social and ecological impacts that degrade both natural resources and the recreation experience. I used a Coupled Human and Natural Systems (CHANS) approach to study recreational use at the Morley Nelson Snake River Birds of Prey National Conservation Area (NCA) in southwest Idaho. This approach considers the human and natural systems, feedbacks within the systems, and effects from telecoupled influences outside of the site, which gives a more complete view and helps to predict how the system may change in the future. The human system at the NCA includes recreationists, management agencies, biologists, recreation organizations, military training, agriculture, and infrastructure. Recreational shooting – shooting inanimate targets or unprotected mammals – is a popular recreational activity at the NCA and was a primary focus of my efforts within the social system. The natural system includes a river with steep cliffs and the surrounding sagebrush-steppe along with raptors, ravens, mammalian scavengers and predators, ground-nesting birds, and small mammals. I used the CHANS framework to identify and investigate questions about the feedbacks within and between the human and natural systems.

In Chapter 1, I focused on how the human and natural systems affect the expected and observed spatiotemporal patterns of recreation at the NCA. I used a multidimensional

survey of recreationists and observational survey routes to characterize the site use of individual recreational shooters and the larger spatiotemporal patterns of recreational use, respectively. Recreational shooters reported a strong preference for sites with natural backstops and generally avoided other groups of recreationists. More experienced shooters placed greater importance on vegetation type and less importance on the presence of other recreationists. Motivation and activity type also affected preference, as individuals who were motivated to view wildlife or hunting unprotected mammals reported a stronger preference for sites with a greater abundance of the most common target species, Piute ground squirrels (*Urocitellus mollis*). Observed spatial patterns of all recreation showed a concentration of recreational use in northern portions of the site and along major access roads with little overlap between shooting and other recreational activities. Observations of recreational use were higher on weekends, earlier in the year, later in the day, on warmer days but not the hottest days, and during the COVID-19 pandemic. These results help to understand the site needs of recreational shooters and how recreational use is currently distributed across the NCA, as well as how these patterns might change in the future as environmental and social conditions change.

In Chapter 2, I examined interactions within social groups associated with the NCA. I asked recreationists, managers, and biologists about their perceptions of recreation impacts, challenges, and management using multidimensional surveys and semi-structured interviews. I focused on recreational shooters, the most common type of recreationists at the site, and birdwatchers, who rely on the natural resources at the site. Recreational shooters were primarily concerned with trash, crowding, and safety, whereas managers and biologists listed a variety of concerns focused on wildlife, habitat,

safety, illegal killing of protected wildlife, lead, and trash. I assessed standards of quality for three levels of trash and crowding that represent conditions at the site, then compared ratings of acceptability between groups using an ordered logistic regression model. Recreational shooters rated low and medium trash conditions as more agreeable than managers, while biologists and birders did not differ from managers. Conversely, recreational shooters rated all crowding conditions as less acceptable than the other groups. Recreational shooters and birdwatchers placed the highest responsibility for enforcing rules on individuals and law enforcement but disagreed on the role of management agencies. Recreational shooters were supportive of educational management interventions whereas birdwatchers supported management changes, recreation participation, and limits on recreational use. Managers and biologists suggested a variety of management actions, including closures, increased law enforcement, and designated shooting areas. From these results, I identified opportunities for improving recreation at the site.

In Chapter 3, I investigated the impact of recreation on multiple trophic levels of the ecological system. I selected 10 paired 1-km^2 sites, with half in areas of high recreation and half in areas of low recreation. I used observational driving survey routes to collect locations of recreational use, mapped a kernel density estimate of recreation locations, then extracted the estimate as a measure of recreation intensity for specific areas and time periods. I assessed the effect of recreational use intensity on the abundance of a keystone prey species (Piute ground squirrels), the abundance of avian and mammalian predators that rely on ground squirrels, and the breeding density and nesting success of ground-nesting birds at the NCA. The abundance of ground squirrels

had a positive relationship with recreation use intensity, potentially due to recreationists selecting sites with squirrels. The presence of native shrub cover had a stronger positive relationship with ground squirrel abundance. The abundance of avian scavengers, particularly common ravens (*Corvus corax*), was positively related to recreational intensity, as well as power lines and development. The density of a common mammalian scavenger, American badgers (*Taxidea taxus*), was positively related to recreational intensity. Breeding bird density and nesting success of ground-nesting birds were negatively related to recreational intensity, with the nest success of a more sensitive species, long-billed curlews (*Numenius americanus*), being most strongly affected. Together, my results highlight the importance of considering variation in recreation intensity, the effect of recreation relative to other conservation threats, and the outcomes for multiple levels of the ecosystem.

Together the results of these chapters give insight into the interactions and feedbacks within and between the coupled human and natural system of recreation at the NCA. This provides a more complete view of the full system to balance the needs of the human and natural systems into the future.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

BSU	Boise State University
BLM	Bureau of Land Management
EEB	Ecology, Evolution & Behavior
IBO	Intermountain Bird Observatory
IDARNG	Idaho Army National Guard
IDFG	Idaho Department of Fish and Game
OCTC	Orchard Combat Training Center
OHV	Off-highway Vehicle
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey

INTRODUCTION

With over eight billion visits to terrestrial protected areas per year globally, outdoor recreation is a cultural ecosystem service of growing importance (Balmford et al. 2015). Participating in outdoor recreation is associated with numerous benefits, including improved health, a connection to nature, and social connections. Outdoor recreationists may gain a heightened awareness and concern for environmental issues and the motivation to engage in behaviors that help the environment, which can positively influence conservation efforts (Zaradic et al. 2009, Halpenny 2010, Larson et al. 2011, 2018a, b, van Riper et al. 2019). However, outdoor recreation may also negatively impact the environment through disturbance of wildlife, decreased wildlife reproduction, degraded habitat, water pollution, and more (Frid and Dill 2002, Beale and Monaghan 2004, Larson et al. 2016, Cole et al. 2019, Sumanapala and Wolf 2019). As the global human population grows and outdoor recreation increases in popularity, research is needed to balance human use and enjoyment of the public lands with safeguarding the wildlife populations that rely on these landscapes.

The need to balance outdoor recreation and conservation is especially prevalent in the western United States where human populations and public land use have expanded rapidly since the 1990s (Hansen et al. 2002, Lybecker 2020). Reported reasons for this increase include a motivation to be near natural amenities, including nature reserves (Hansen et al. 2002). As such, we might expect recreation participation to have experienced a disproportionately high increase during the same time frame. It is

particularly urgent to consider multiple-use public lands near growing urban areas. At these sites, population growth and the popularity of outdoor recreation create high demand for access to nearby public areas, which could threaten natural resources that attract visitors to the site and are mandated protection.

My research was conducted, and made use of other data collected, at the Morley Nelson Snake River Birds of Prey National Conservation Area (NCA) located approximately 30 km south of Boise, Idaho. The NCA includes a river canyon with abundant cliff-side nest sites for raptors as well as extensive areas of shrub steppe and grasslands adjacent to the canyon which provide habitat for a variety of mammalian and avian prey species for the raptors. The Bureau of Land Management (BLM) manages the NCA and jointly manages a Department of Defense training center within the NCA with the Idaho Army National Guard (IDARNG). Differences in management (private versus public land) and accessibility throughout the NCA create a unique outdoor laboratory with a mosaic of land-use intensities that span multiple vegetation types. The NCA is representative of outdoor recreation and protected natural areas on public lands across the western United States that are experiencing increased recreational use and tensions between opportunities for recreation and wildlife conservation.

Recreational shooting is a popular activity on the NCA and multiple-use public lands in the western United States. This term encompasses a variety of activities, including killing unprotected mammal species not intended for consumption, sighting in a rifle, and shooting inanimate targets. These activities can take place in various locations, from an indoor shooting range to structured ranges outdoors to public or private lands without shooting infrastructure. Recreational shooting is understudied, except in

investigations focused on environmental lead (Pauli and Buskirk 2007, Herring et al. 2016, 2021, McTee et al. 2017, 2019). There is little information available regarding other ways recreational shooters impact the environment, how the environment influences recreational shooters, or even the general characteristics, behaviors, and motivations of this group. Local agency managers, biologists, and law enforcement officers have observed a dramatic increase in the number of people engaged in recreational shooting on public lands over the last several decades (A. Hoffman, Bureau of Land Management NCA Manager; B. Flatter, Idaho Department of Fish and Game Law Enforcement Officer; C. Baun, Idaho Army National Guard Conservation Branch Manager; pers. comm.), including a tripling of visitors to a BLM recreation site since 2011 (Bureau of Land Management, unpubl. data) and a doubling of visitors to a public shooting range since 2014 (Idaho Department of Fish and Game, unpubl. data). Recreational shooting is also associated with negative environmental impacts, including the illegal killing of protected species. A recent survey of avian carcasses at a National Conservation Area in southwestern Idaho found that 60% of carcasses with a known cause of death had been shot, despite their protected status, and that illegal shooting of protected birds was spatially linked to areas of high legal recreational shooting use (Katzner et al. 2020). The illegal shooting of protected wildlife highlights the need to better understand the motivation, behavior, and spatial and temporal use patterns of participants in the increasingly popular activity of recreational shooting. I focused on recreational shooting at the NCA and the broader system of recreation in which recreational shooting occurs.

The Coupled Human and Natural Systems Framework

Previous studies of recreation have overwhelmingly examined the social and ecological impacts of the activity separately, with a focus on direct impacts (Sumanapala and Wolf 2019, Miller et al. 2021). However, this overlooks the ways that outdoor recreation impacts human participants and the environment through a system of feedbacks between and within the human and natural systems. Recent reviews have called for an integration of the social and ecological components of outdoor recreation in frameworks that account for the complexity and adaptive nature of the full system (Morse 2020, Rice et al. 2020, Miller et al. 2021).

A useful framework for considering both the social and environmental elements of outdoor recreational use on public lands is a coupled human and natural (CHANS) systems framework, which integrates environmental and social perspectives to study the linkages between human and natural subsystems (Liu et al. 2007, Carter et al. 2014). The CHANS framework includes social and environmental factors at various scales and the patterns and processes that link the two systems, which can be applied to specific systems (Table I.1). A key element of the CHANS framework is the consideration of feedbacks between and within the systems. The framework also considers how systems may be affected by telecoupling processes across spatial and temporal scales (Liu et al. 2007, Carter et al. 2014).

Table I.1. The components of a Coupled Human and Natural System (CHANS), a general description, and how that component applies to recreation at the Morley Nelson Snake River Birds of Prey National Conservation Area (NCA) in southwestern Idaho. Components were assigned following Liu et al. (2007) and Carter et al. (2014).

CHANS Component	General Description	Applied to recreation at the NCA
Social community	Organizations, services, infrastructure, and networks	Land and wildlife management agencies, infrastructure (roads, signs), and informal or formal user groups (i.e., Idaho Varmint Hunters, an ATV club, the Golden Eagle Audubon Society)
Individual Recreationists	Demographics, behaviors, socioeconomic status, education	Primarily white, male, local residents with varied socioeconomic status and educational backgrounds
Landcover	Spatial distribution, composition, structure	Desert ecosystem - sagebrush steppe, non-native annual grasslands, a major river and cliffs
Wildlife	Species, populations, distribution, behavior	Ground squirrels, ground-nesting birds, diurnal raptors, avian and mammalian scavengers
Telecoupling	Tourism, conservation policy, rural-urban migration	Rapid urbanization, tourism, local, state, or national conservation policy, increase in human impact over time, wildlife migration, COVID-19 pandemic, price of gasoline and ammunition

Coupled human and natural systems are inherently adaptive and dynamic, making them resilient and able to recover after disturbances (Cote and Nightingale 2012). However, there are thought to be thresholds to this adaptive capacity (Liu et al. 2007).

The increased amount of recreational use on public lands could be reaching one of these thresholds. Studying recreational shooting on public lands will advance our understanding of the resilience of CHANS being affected by increased human use.

My research identified feedbacks among recreationist behavior and experiences, protected wildlife species, and management agencies, and how these interactions may change as the system continues to develop (Figure I.1).

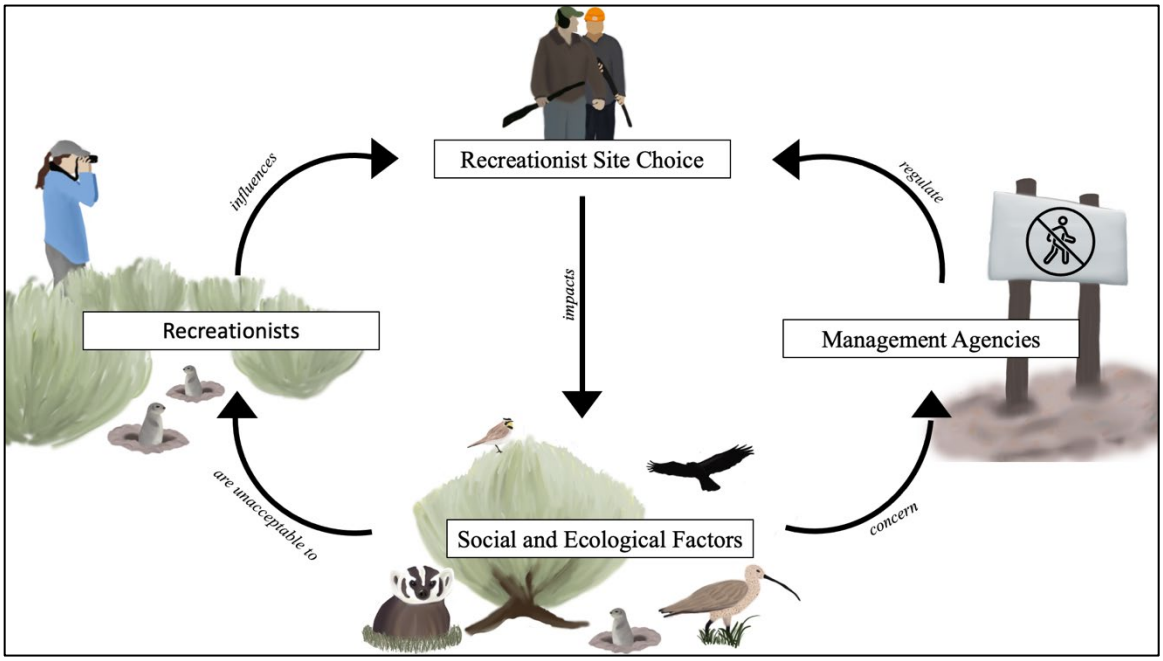

Figure I.1. Diagram of key hypothesized interactions between the human and environmental components of the coupled system of recreation on public lands.

My first and second chapters focused on the interactions within the social system and the impact of the environment on recreation. In Chapter 1, I examined how recreational shooters use social and ecological factors to select sites and the resulting spatiotemporal patterns of use on the landscape. In Chapter 2, I assessed the perceptions of recreation impacts, challenges, and management among key social groups within the system: recreational shooters, birdwatchers, managers, and biologists. In Chapter 3, I examined the impacts of recreation on the environment, specifically the abundance of a

keystone prey species and common shooting target, Piute ground squirrels (*Urocitellus mollis*), the abundance of avian and mammalian scavengers and predators, and the breeding density and nesting success of two ground-nesting birds. In the Conclusion, I used the results from all chapters to create a table of potential management actions and the rationale for each based on this research and other empirical evidence. By studying the integrated socio-environmental feedbacks of outdoor recreation on public land, we can better understand the dynamic relationship between recreation and wildlife on shared landscapes while providing management-relevant information for natural resource agencies and advancing our understanding of the resilience of an integrated coupled human and natural systems in the rapidly growing West.

CHAPTER ONE: EXPECTED AND OBSERVED SPATIOTEMPORAL PATTERNS OF RECREATION ON LOW-INFRASTRUCTURE PUBLIC LANDS

Abstract

Recreational use is increasing on public lands in the western United States, including areas without recreation infrastructure. At our study area, and on public lands throughout the western U.S., recreational shooting is a popular activity with the potential for social and ecological impacts. Our study characterized the site use of individual recreational shooters and the larger spatiotemporal landscape patterns of all recreational use at a National Conservation Area in southwestern Idaho, USA. We implemented a multi-modal survey of recreationists and observational survey routes. We also compared observed use to predictions from two maps of habitat suitability for recreational shooting. Recreational shooters reported a strong preference for sites with natural backstops to shoot into and generally avoided other groups of recreationists. Site preferences were related to experience, with more experienced shooters placing more importance on vegetation type and less importance on the presence of other recreationists. Motivation and activity type also affected preference, as hunters and shooters who were motivated to view wildlife reported a higher preference for sites with higher abundance of the most common target species, Piute ground squirrels (*Urocitellus mollis*). Observed spatial patterns of all recreation showed that recreational use was concentrated in the northern portions of the site closest to a major urban center and along major access roads with little overlap between shooting and other recreational activities. Recreational use was

higher on weekends, earlier in the year, later in the day, on warmer but not the hottest days, and during the COVID-19 pandemic. Predictions of habitat suitability for recreational shooting overpredicted use further into the site and under predicted use in popular locations off the main access road.

Management Implications

- Areas further into the NCA that are predicted to be suitable for recreational shooting but are not currently used heavily should be monitored as use continues to increase and expand into the site. This will help managers be aware of new impacts or conflicts as use spreads.
- Recreational shooters place high importance on finding spots with a backstop, but many backstops are low or rocky, which makes them less effective at stopping all bullets and ricochets. Adding or improving backstops in high use areas may direct use to safer sites.
- Providing cues to direct use could help to indirectly manage visitors without an increase in management personnel.

Introduction

Over the past 30 years, the number of outdoor recreational users visiting protected areas in the western United States has increased rapidly (Lybecker 2020). Outdoor recreation provides benefits to individual users, communities, and conservation initiatives (Winter et al. 2020, Miller et al. 2021). However, increased recreational use may lead to negative ecological impacts that affect protected natural resources (Sumanapala and Wolf 2019). More people using a site can also negatively affect the experience of recreational users (Allen 2019). This may lead to changes in behavior, such as more experienced users

or individuals who want solitude traveling further into a protected area or finding a new site entirely (Butler 1980, Frey et al. 2018, Fefer et al. 2021). This could result in different types of impacts or a larger spread of impacts throughout the site. Managing the rapidly changing system of recreation on public lands requires an understanding of the feedbacks between recreation and the social and ecological systems (Morse 2020, Miller et al. 2021, McCool 2022).

Site choice is an aspect of recreation that is affected by feedbacks between and within the social and ecological systems. Outdoor recreationists choose the location where they recreate based on social factors, such as spending time with other recreationists (Frey et al. 2018), balancing reduced crowding with accessibility (Tratalos et al. 2013), and staying within an accessible distance of major cities and roads (Pauli et al. 2019). Recreationists also use environmental factors, including the potential for viewing wildlife or aesthetically pleasing habitat (Opdahl 2018). Within the social system recreationists affect one another, and the behaviors of one group could lead to changes in the site choice of another. Changes in recreationist behavior and site use alter the impacts to the environmental systems. Conversely, impacts to the environmental system, such as degraded resources, impact the behaviors of recreationists once they no longer consider a site suitable (Butler 1980, Opdahl et al. 2021). A more mechanistic understanding of how recreationists select sites can help to predict how patterns of use might be altered with changing demographics, environmental conditions, or management interventions.

The site choice decisions of individual recreationists lead to broader spatiotemporal patterns of visitor use. There is a growing recognition of the importance of studying the spatial and temporal patterns of visitor behavior in protected areas, as

understanding where visitors go within a protected area and why they go those places can help to manage their experiences and impacts (Beeco and Brown 2013, Riungu et al. 2018, Peterson et al. 2020a). Site use by recreationists has most often been examined in national parks or other protected areas with a high degree of infrastructure and visitor support (Braunisch et al. 2011, Sumanapala and Wolf 2019). In these protected areas, recreationists are given many cues about how to move through the site, including trails, signs, information kiosks, and visitor centers. Recreationist site use in areas with less formal recreation infrastructure offers opportunities for examining this phenomenon in a free-ranging context (Braunisch et al. 2011). As the population of urban areas in the western United States grows rapidly, low-infrastructure public lands are experiencing increased recreational use overall and by novice users in particular (Lybecker 2020), making it important to consider these sites in studies of recreationist site choice and potential ecological effects. At sites with low infrastructure, some of the techniques that have been used in studies of visitor behavior, such as GPS tracking (i.e., D'Antonio et al. 2013), might not be applicable because of logistical challenges, personnel availability, or a lack of cooperation and trust from the visitor group. In these systems, passive or less invasive methods of studying visitor use are needed.

We studied the individual site choice and landscape use patterns of recreationists in at a National Conservation Area (NCA) in southwestern Idaho with high levels of recreational shooting. Recreational shooting in southwestern Idaho encompasses a variety of activities, including killing Piute ground squirrels (*Urocitellus mollis*) and other unprotected mammalian species, sighting in a firearm, and shooting inanimate targets (Pauli et al. 2019, Katzner et al. 2020). These activities have been popular on public lands

in the United States for over 100 years (Reeve and Vosburg 2013), but few standardized studies or comprehensive databases exist. Recreational shooting often occurs in areas with little recreation infrastructure that could direct use and aid in the prediction of future use. The free-ranging nature of recreational shooting also increases the potential for conflicts with wildlife and other users (Braunisch et al. 2011). We focused on recreational shooting because it is thought to be the most prevalent type of recreation at the study site (Pauli et al. 2019), the user group is relatively unstudied, and there are concerns about illegal shooting of protected wildlife that is correlated with areas of legal recreational shooting use (Katzner et al. 2020). We also considered the larger suite of recreational use in which shooting occurs.

With an improved understanding of recreationist site choice, we can improve our ability to predict how site choice might change as visitation continues to increase, the types of visitors change, or management actions are implemented (Vaske 2008). We can also identify areas of potential conflict between recreationists or where ecological resources are at a higher risk. Together, this can provide more actionable findings for management agencies. Our study objectives were to characterize recreational use at the individual and landscape scale and compare observed use with expected use at the landscape scale. We examined several specific research questions (RQs). RQ1: How do individual recreationists' preferences for site selection factors relate to their activity type, experience, and motivation? RQ2: How does recreation at the NCA vary spatially and temporally? RQ3: Do landscape patterns of use vary between recreational shooting and other activity types? RQ4: How do observed patterns of use compare to two maps of expected habitat suitability for recreational shooting use? One map of expected use was

from a past study of recreational shooting at the NCA (Pauli et al. 2019), and the other was defined using the reported preferences of recreational shooters. We focused on recreational shooting but also characterized observed patterns of use for other types of recreation at the site.

Effect of Recreationist Characteristics on Site Preferences

Studies of the site preferences of recreational shooters are limited. A study of habitat suitability for recreational shooters in the study area based on observed shooting locations found that shooting tended to occur in areas closer to metropolitan areas and access roads but was not related to vegetation type or elevation (Pauli et al. 2019). However, this study did not directly ask shooters how they selected sites. There are additional factors that may affect site choice decisions, including crowding, the presence of a hill to shoot into (hereafter, a backstop), or the abundance of ground squirrels at a site.

We were interested in how preferences for factors vary by individual. Site choice preferences may vary within a user group based on the characteristics of each recreationist. Activity type affects the site preferences and behaviors of recreationists within the same recreation area (Baker et al. 2021, Sisneros-Kidd et al. 2021). Motivation and experience can also impact recreationist preferences, resulting in differences in site choice among recreationists participating in the same outdoor activities (Frey et al. 2018, Komossa et al. 2019, Pearce and Dowling 2019). For example, recreationists who want to enjoy nature or view wildlife seek out particular habitat features or more biodiverse areas (Opdahl et al. 2021). Recreationists who are motivated by a desire to experience solitude are more affected by crowding and travel further into the site, while recreationists who

are motivated to spend time with friends and family stay closer to the entrance and are less affected by crowding (Frey et al. 2018). Experience may also affect site preferences, as more experienced users tend to be more specialized in their activity and have more specific habitat requirements (Bryan 1977). We expected that the characteristics of recreational shooters would affect their site preferences.

H1: Recreational shooter site preferences are related to their activity type (hunting ground squirrels or not), years of experience, and strong motivations to enjoy nature, experience solitude, view wildlife, and spend time with family and friends. We predicted that more experienced shooters would place greater importance on habitat features for their activity, such as vegetation, vantage points, and backstops, that ground squirrel hunters would place higher importance on ground squirrel abundance while other shooters would not select sites based on ground squirrels, and that shooters motivated to enjoy nature or experience solitude would place greater importance on minimal crowding, while shooters who were motivated to spend time with family and friends would place less importance on avoiding crowds.

Spatiotemporal Patterns of Recreational Use

Within a recreation area, use tends to be concentrated near attractions and visitor features, causing differences in the amount of use across the site (Peterson et al. 2020b, Sisneros-Kidd et al. 2021). Most visitors spend their time near their entrance point, while a smaller group travels through the site (Peterson et al. 2020b, Baker et al. 2021). User groups tend to be separated in space when they have activity-specific spatial requirements, such as bike trails or waterfront access (Rice et al. 2020, Baker et al. 2021). In most recreation areas, outdoor recreational use is typically most prevalent during the

summer with moderate use in the spring and fall and reduced use in the winter, although these trends vary geographically with less summer visitation in warmer climates (Wilkins et al. 2021). Within a season, the amount of recreational use is affected by the time of day, temperature, and day of the week (Peterson et al. 2020b). The COVID-19 pandemic affected recreational use in many areas, as areas closer to urban areas received more visitors as national parks closed and travel was restricted (Hockings et al. 2020, Jacobs et al. 2021). This was particularly prevalent during the initial months of the pandemic as recreation activity spiked when local governments placed restrictions on non-essential businesses and travel, then declined as restrictions lifted (Rice et al. 2020). In Idaho, an Order to Self-Isolate (hereafter, the Stay Home Order) was issued on 25 March 2020 and extended until 30 April 2020 (Idaho Department of Health and Welfare 2020a). The Order restricted non-essential business but allowed outdoor activities as long as distances of 6 ft could be maintained. After 30 April 2020, businesses reopened with social distancing and sanitation requirements as directed by the Stay Healthy Order (Idaho Department of Health and Welfare 2020b). In other areas, a decline in restrictions led to a partial or full reduction of the increase in use at local recreation areas observed during the most restricted period (Rice et al. 2020).

H2: The amount of recreational use observed is driven by location, temperature, date, time of day, weekdays versus weekends, and the timing of the COVID-19 pandemic. We predicted that use would be highest on routes closest to Boise, earlier in the year, later in the day, in warmer temperatures, on weekends, and during the COVID-19 pandemic.

H3: Spatiotemporal patterns of use vary between recreational shooters and other recreationists at the site. We predicted that recreational shooters and other recreationists would be concentrated in separate sites based on activity requirements and preferences. We expected to see similar temporal patterns in use.

Comparison of Observed and Expected Site Use

We compared observed site use to two methods used to predict recreational site suitability that are feasible on low-infrastructure public lands. The first method is based on the reported site preferences in our study for vegetation, evaluation (vantage points), and backstops. This follows a methodology used by Gül et al. (2006) that involved asking visitors to rank site selection factors, weighing each factor, and mapping the weighted values based on spatial covariates to produce a map of habitat suitability. A benefit of this method is that it is based on reported preferences from recreationists. However, response bias or inaccurate responses may lead to inaccurate predictions. Hereafter, the map created with this method is referred to as the self-reported preference map.

A second study applied a MaxEnt presence-only habitat suitability used in wildlife ecology to recreational use (Pauli et al. 2019). The authors surveyed our study site using three driving routes in the northwest of the site from 28 February to 14 March 2015. Their model included distance to the nearest urban area, distance to the nearest major road, land cover, and elevation as predictors of shooting location and found the most support for distance to urban center and major roads. They used these predictors to create a map of habitat suitability for recreational shooting, which we compared with observed patterns of use estimated using the same driving route procedure with additional

routes throughout the site that were sampled over a longer time period. Hereafter, this map is referred to as the Pauli et al. (2019) map.

Study Context

Our study was conducted at the Morley Nelson Snake River Birds of Prey National Conservation Area (hereafter, NCA), located approximately 30 km south of Boise, Idaho (Figure 1.1). The Bureau of Land Management (BLM) manages the NCA and jointly manages a portion of the area, the Orchard Combat Training Center (OCTC), with the Idaho Army National Guard (IDARNG). The NCA was established in 1993 in recognition that the area contained the largest and densest population of nesting raptors known in North America (Public Law 103-64). Multiple types of public recreation are permitted throughout the NCA, with the exception of areas used for military training exercises where all public use is restricted (Impact Zone) and areas where shooting use is restricted for human safety (see Figure 1.1). Recreational shooting of inanimate targets and ground squirrels is particularly popular at the site and is estimated to draw thousands of visitors per week during the peak season (Walter 2016). Other recreation at the site includes off-highway vehicles (OHV), hiking, photography, fishing, boating, camping, and climbing. Pauli et al. (2019) predicted use across the site based on predicted habitat suitability defined using late winter observational surveys in the heavily used northeastern area of the NCA, but the distribution of recreationists across the NCA and throughout the year was previously unknown. Differences in management (public versus private land) and accessibility throughout the NCA create a unique outdoor laboratory with a mosaic of land-use intensities that span multiple vegetation types (sagebrush, native grasses, and exotic annual vegetation). This site is representative of recreational

shooters on public lands across the western United States, as recreational shooting of ground squirrels and prairie dogs (*Cynomys spp*.) occurs in many areas of the West (Pauli and Buskirk 2007, Herring et al. 2016). In areas with high amounts of recreational shooting, illegal killing of protected wildlife species has been documented at the NCA (Katzner et al. 2020).

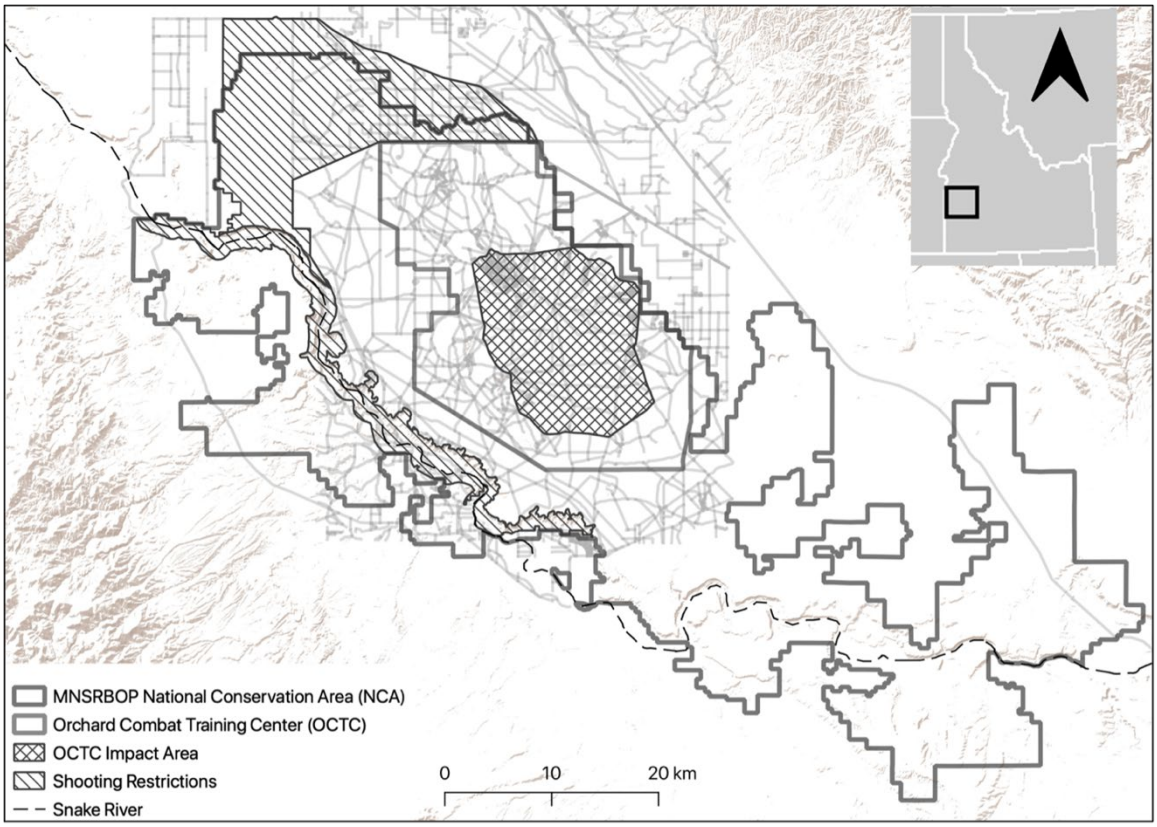

Figure 1.1. Map of the Morley Nelson Snake River Birds of Prey National Conservation Area (NCA) in southwestern Idaho, including land ownership and boundaries of land managers within the NCA. The Orchard Combat Training Center Impact Area excludes any public access. Areas with shooting restrictions allow public access and other types of recreation.

Methods

Field Methods

Multi-modal Surveys

We used information gained during a pilot field season (April - August 2019; Appendix D) to design online and on-site questionnaires to understand the motivations, perceptions of site suitability, and constraints of recreationists at the NCA (Appendices E, F, G). In the multi-modal surveys, we incorporated close-ended questions, free listing, rank ordering, and paired comparisons (Bernard 2011). All survey procedures and questions were reviewed and approved by Boise State University's Institutional Review Board and the NCA management agencies. All personnel completed CITI training for Human Subject Research prior to surveying participants. We pre-tested the survey with members of the recreational shooting community prior to the study.

Online Survey Distribution

We surveyed individual recreationists from a sampling frame of recreation-based organizations in southwestern Idaho that included interest groups (i.e., Idaho Varmint Hunters, Boise ATV Trail Riders, Idaho Outdoor Association), shooting ranges, and sporting goods stores. From 17 April 2020 to 31 October 2021, we distributed the survey with Qualtrics software (Qualtrics, Provo, UT, USA). Because no publicly available, comprehensive list of recreationists in southwestern Idaho exists, we distributed the survey to a publicly-listed contact person for each group or institution who then distributed the survey to their contact list. We sent up to three emails to each contact person during the survey period. We also advertised the survey at sporting goods stores and indoor shooting ranges through the duration of the survey.

On-site Survey Distribution

We administered a similar but shortened survey to recreationists on-site at the NCA where we intercepted visitors along access roads from 13 March to 25 July 2021. We used a stratified random approach with two strata of days – weekdays and weekend/holidays – to select survey days. On selected days, we surveyed for 1 – 4 hours at a survey location along the NCA access roads (Appendix A). We placed signs along the road in either direction to advertise the study. When an individual or group stopped, we gave them a brief overview of the survey purpose and content, then asked one individual in the group to participate. We provided participants who expressed interest but did not have time to complete the survey on-site with information about how to access the online version of the survey. We delivered the survey questions as an interview, which gave participants the chance to elaborate on their responses. We took notes of additional responses, which are paraphrased to contextualize survey results.

Driving Survey Routes

We used driving routes to assess actual recreational use of the landscape. We selected 12 driving routes that passed through a variety of land cover types and utilize publicly accessible major and minor roads across the NCA (Figure 1.2). We had two subsets of driving routes (Table 1.1). An NCA-wide subset of 10 routes was meant to assess recreational use of the entire site (hereafter, NCA-wide Subset), while a subset of 2 routes in the northern portion of the site was meant to assess use on a finer scale in the highest use area within the Orchard Combat Training Center, which is jointly managed by the Bureau of Land Management and the Idaho Army National Guard to support public access and military training activities (hereafter, OCTC Subset; Pauli et al. 2019,

personal observations). From 15 May 2019 to 17 July 2021, we drove the NCA-wide Subset routes, each 16 km in length, each Saturday during peak recreational shooting season (March to July), once per month on a randomly selected Saturday during the off season (August to December), and twice per month in the early season (January to February). We drove the OCTC Subset routes from 17 July 2019 to 26 June 2020. The OCTC Subset routes included a northern route (111 km) and a southern route (86 km). We drove the northern route on two Saturdays, two Sundays, and one Monday, Tuesday, Wednesday, Thursday, and Friday each month. We also drove the northern route on one holiday per month, with the exception of July 2019 because the surveys started after holidays and August 2019 which has no calendar holidays. We drove the southern route on one weekend day and one weekday per month in addition to the northern route scheduled for that day. We varied the order that routes were driven within both subsets to avoid conflating route or location with time of day.

Table 1.1. Sampling effort for driving route surveys at the Morley Nelson Snake River Birds of Prey National Conservation Area in southwest Idaho.

Routes	Survey Dates	Route Length	Sampling Frequency
NCA-wide Subset (*n = 10*)	15 May 2019 – 17 July 2021	16 km	• Every Saturday from March to July • One Saturday per month from August to December • Two Saturdays per month from January to February.
OCTC Subset – northern route	17 July 2019 – 26 June 2020	111 km	• Two Saturdays, 2 Sundays, 1 Monday, 1 Tuesday, 1 Wednesday, 1 Thursday, 1 Friday, and 1 holiday* per month
OCTC Subset – southern route	17 July 2019 – 26 June 2020	86 km	• One weekend day and one weekday per month

* No holidays were sampled in July 2019 or August 2019

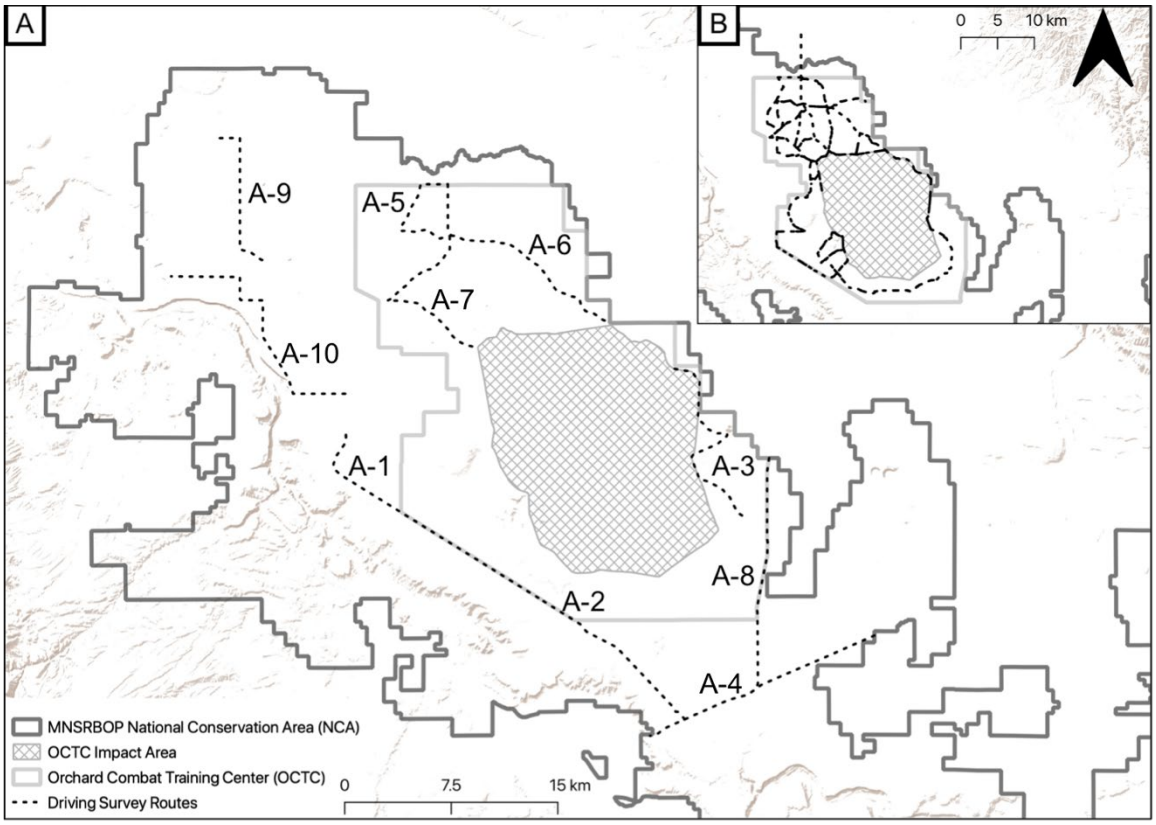

Figure 1.2. Driving survey routes used to assess patterns of recreation at the Morley Nelson Snake River Birds of Prey National Conservation Area in southwestern Idaho from April 2019 to July 2021. Map A displays the NCA-wide Subset routes, 10 routes that were each 16 km in distance and used to assess use across the National Conservation Area. Map B displays the northern (111 km) and southern (86 km) OCTC Subset routes, which were used to assess recreation in the heavily used northern portion of the site within the Orchard Combat Training Center.

During the survey routes, we recorded the location, number of people, and number of vehicles, and the dominant overstory and understory vegetation for each recreationist event observed during the routes. We categorized overstory vegetation as big sagebrush (*Artemisia tridentata*), rabbitbrush (*Chrysothamnus viscidiflorus*), winterfat (*Krascheninnikovia lanata*), forage kochia (*Bassia prostrata*), no overstory, or unknown. We categorized the understory as bare ground, cheatgrass (*Bromus tectorum*), exotic annual vegetation, native perennial grasses, Sandberg bluegrass (*Poa secunda*), road, rocks, or unknown. The exotic annual vegetation category included a variety of

forbs, most commonly burr buttercup (*Ceratocephala testiculata*), Russian thistle (*Salsola tragus*), or tumble mustard (*Sisymbrium altissimum L.*). Cheatgrass was categorized separately because of differences in the density and height at which it grows that might affect recreation preferences. When possible, we recorded the observed demographics of a recreation group, including gender and the number of children. We did not record any identifiable information about the recreationists observed. We classified recreational use as motorized recreation (off-highway vehicles, driving off-road), target shooting (shooting at targets or other inanimate objects, stationary), hunting ground squirrels (moving through vegetation and shooting, no inanimate targets), non-motorized recreation (hiking, birdwatching, biking), or other (camping, photography). We combined target shooting and hunting into one category of recreational shooting for subsequent analyses.

Analyses

We conducted our statistical analyses in R (R 4.1.2, RStudio 2022.02.0; R Core Team 2021) and used QGIS (Version 3.16; QGIS Development Team 2022) to create maps.

Effect of Recreation Characteristics on Site Preferences

We used a rank order question adapted from Gül et al. (2006) to assign site suitability values (Figure 1.3). We used information gained during our multi-dimensional surveys to define site suitability for recreational shooters using equations adapted from Gül et al. (2006; Equations 1.1, 1.2). For each factor we summed all rank scores to find the total value (TVF_m), then averaged the total value for that factor. We also calculated the weighted value (WCF_m), which incorporated the total number of factors and survey

participants. *VF* was the rank given to a factor by survey participants (1-5, Figure 1.3), *m* was the total number of factors (5), and *n* was the total number of survey participants.

(Eq. 1.1) $$Total\ Value\ (TVF_m)\ =\ \sum_n^m VF$$

(Eq. 1.2) $$Weighted\ Value\ (WCF_m) = m - \frac{(\frac{TVF_m}{n})}{m}$$

What is important to you when selecting a site for recreational shooting? Rank the following factors from 1 (most important) to 5 (least important):

- ☐ vegetation type
- ☐ vantage points
- ☐ backstops
- ☐ ground squirrel density
- ☐ presence of other recreationists

Figure 1.3. A rank order question to assess how recreationists value site suitability factors (adapted from Gül et al. 2006).

We used ordered logistic regression models to assess if the rank of each factor was affected by the motivations, experience, or activity of recreational shooters. We included ground squirrel shooting participation, years of shooting experience, and 4 top motivations - enjoying nature, experiencing solitude, spending time with friends and family, and viewing wildlife - as potential predictors. We included a variable for survey format to assess if online or on-site sampling affected the outcome. We used additional survey questions to contextualize the site selection equation results and examine reasons why recreationists may not be able to use their preferred sites.

Spatiotemporal Patterns of Recreation

We summarized the demographics of recreationists, proportion of use by type of recreation, and the amount of use throughout the duration of the study using the full set of 12 driving routes. To examine recreational hotspots across the site, we mapped a Gaussian kernel density estimate of the locations of recreational shooting and other recreation observations. The kernel density estimate used a probability density function to explain the continuous process that gave rise to the point pattern of our recreation observations. We created a kernel density estimate using points from both subsets of routes. To account for differences in the sampling effort of the routes, we weighted points by the survey effort for the route within the kernel density estimation (Eq. 1.3, Eq. 1.4).

(Eq. 1.3) $$Total\ Effort = Route\ Length \times Times\ Surveyed$$

(Eq. 1.4) $$Weighted\ Effort = \frac{Max\ Total\ Effort}{Route\ Total\ Effort}$$

To examine the drivers of recreational use, we modeled the number of recreation observations per survey day using a Poisson generalized linear model with day of year, time of day, temperature, weekend or weekday, and the COVID-19 pandemic as predictors. The COVID-19 pandemic was included as a categorical variable with 3 levels: pre-pandemic (up to 24 March 2020), during the Stay Home Order in Idaho (25 March to 30 April 2020), and after the Stay Home Order (1 May 2020 and after). We converted day of year to radians to account for the circular nature of the variable. We included time as a polynomial because we expected recreational use to increase with temperature to a point, then to decrease at the hottest temperatures. We standardized all predictors to facilitate the comparison of effect sizes (Gelman 2008) and tested for multicollinearity prior to modeling. We included route ID as a random intercept. We included all routes in

the model and used an offset to account for differences in route length. We created separate models for shooting observations and other recreation using the same predictors. We checked the model residuals for spatial autocorrelation.

Comparison of Recreational Shooting and Other Recreation

We created a kernel density map of all recreational shooting use and another of all other types of recreational use. To compare patterns of recreational use between recreational shooting and other types of recreation, we scaled the pixel values of each map to a 0 – 1 scale, then subtracted one map from the other to assess the degree of overlap.

Comparison of Observed and Expected Patterns of Recreational Shooting

To create our self-reported preference map, we created one map layer for site selection factors (elevation, vegetation cover, backstops) with each cell given a score based on the weighted value of that factor, then overlaid the maps on a grid. Each grid cell was assigned a suitability value based on the factors present (Gül et al. 2006). The Pauli et al. (2019) map of expected use is detailed in its original manuscript.

To compare expected and observed patterns of recreational use, we created a kernel density map of each, scaled the map pixel values to a 0 – 1 scale, then subtracted one map from the other to assess the degree of overlap.

Results

Survey Samples and Recreationist Characteristics

Multi-modal Survey Samples

In total, 116 recreationists (54 recreational shooters, 62 other recreationists) responded to our in-person or online survey, but we removed any online survey

respondents who did not recreate at the NCA at least once per year. This left a total of 103 recreationists, 42 of these were recreational shooters and 61 were other recreationists (Table 1.2). When surveying on-site at the NCA, 19% of recreation groups who stopped or drove past slowly enough to read our sign agreed to be interviewed (Appendix A). We contacted 22 shooting-based recreation organizations and 11 organizations focused on other types of recreation (ATV/OHV riding, birding, a jeep club, and more general groups), all of which were based in southwest Idaho. Out of the organizations we contacted, 7 shooting organizations (31.8%) and 4 others (36.4%) agreed to distribute the survey to their list serv. We displayed the survey at 10 sporting goods and shooting stores. We were not able to calculate a response rate for our online survey sample because the number of potential participants who received emails from their recreation group or saw a sign was unknown. Other recreationists included people whose primary form of outdoor recreation was hiking (n = 23), birdwatching (n = 20), fishing (n = 3), OHV (n = 3), water sports (n = 3), falconry (n = 2), camping (n = 1), golf (n = 1), horse riding (n = 1), mountain biking (n = 1), road cycling (n = 1), running (n = 1), and unspecified (n = 1).

Table 1.2. Sample size for each survey type and format. On-site interviews were conducted at the Morley Nelson Snake River Birds of Prey National Conservation Area from March to July 2021. Online surveys were distributed in the larger Boise, Idaho, metropolitan area from April 2020 to October 2021.

Survey Format	Sample Size
On-site Interviews	24
Recreational Shooting	23
Other Recreation	1
Online Surveys	79
Recreational Shooting	19
Other Recreation	60

The majority of survey respondents were male (51%), and the subgroup of recreational shooting participants was almost entirely male (96%; Table 1.3). The age of survey participants ranged from 20 to 80 years old (mean ± SD = 51.7 ± 15.8 years). A large majority (88%) of survey participants were from Idaho, and 100% of participants contacted at the NCA were Idaho residents. Of the survey participants who were Idaho residents, 64% lived in Ada County and 19% in Canyon County, which are both in the Boise metropolitan area. Recreationists had between 1 – 60 years of experience (24.3 ± 16.0 years; Table 1.3) and reported that enjoying nature and having fun were the most important motivations (Appendix A).

Table 1.3. Demographics of survey respondents summarized by survey format. Questions that were not asked in a particular survey are left blank. In cases where not all participants answered a question, summary statistics are based on the participants who answered. On-site interviews were conducted at the Morley Nelson Snake River Birds of Prey National Conservation Area from March to July 2021. Online surveys were distributed in the larger Boise, Idaho, metropolitan area from April 2020 to October 2021.

Demographic	Overall (n = 103)	On-site Shooting (n = 23)	Shooting Online (n = 19)	All Rec Online (n = 60)
Respondent Gender % (n)				
Male	58 (53)	96 (23)	100 (14)	30 (16)
Female	42 (38)	4 (1)	0 (0)	70 (38)
Age (mean ± SD)	51.7 ± 15.8	39.9 ± 17.0	52.9 ± 14.6	56.3 ± 13.1
Youngest	20	21	20	29
Oldest	80	70	72	80
Residence % (n)				
Boise Metropolitan Area	84 (86)	96 (22)	63 (12)	87 (52)
Other Idaho	4 (4)	4 (1)	5 (1)	3 (2)
Out of State	12 (12)	0 (0)	32 (6)	10 (6)
County (For Idaho Residents) % (n)				
Ada County	75 (66)	100 (22)	62 (8)	68 (36)
Canyon County	23 (20)	0 (0)	31 (4)	30 (16)
Jerome County	1 (1)	0 (0)	7 (1)	0 (0)
Twin Falls	1 (1)	0 (0)	0 (0)	2 (1)
Years at current residence (mean ± SD)	26.4 ± 18.0	22.5 ± 17.2	25.1 ± 19.3	28.3 ± 18.1
Number of People in Household (mean ± SD)	2.3 ± 0.9		2.6 ± 1.2	2.2 ± 0.8
Annual Household Income % (n)				

Less than $20k	0 (0)		0 (0)	0 (0)
$20 - 29k	2 (1)		8 (1)	0 (0)
$30 - 39k	5 (3)		8 (1)	4 (2)
$40 - 49k	12 (7)		23 (3)	9 (4)
$50 - 59k	10 (6)		0 (0)	12 (6)
$60 - 69k	10 (6)		0 (0)	12 (6)
$70 - 79k	8 (5)		8 (1)	9 (4)
$80 - 89k	18 (11)		15 (2)	19 (9)
$90 - 99k	8 (5)		0 (0)	11 (5)
$100 - 149k	15 (9)		15 (2)	15 (7)
Over $150k	12 (7)		23 (3)	9 (4)
Education Level % (n)				
Less than high school	1 (1)	0 (0)	7 (1)	0 (0)
High School Diploma/GED	9 (8)	18 (4)	14 (2)	4 (2)
Associate Degree	27 (24)	23 (5)	43 (6)	24 (13)
Bachelor's Degree	35 (32)	32 (7)	29 (4)	39 (21)
Graduate Degree	28 (25)	27 (6)	7 (1)	33 (18)
Years of recreation experience (mean ± SD)	24.3 ± 16.0	18.1 ± 14.0	35.6 ± 11.2	23.7 ± 16.4
Minimum	1	1	13	2
Maximum	60	50	52	60

Driving Survey Samples

We observed a total of 2,911 groups of recreationists during our driving surveys, which consisted of a total of 681 total visits to the 12 routes, or 21,712 km of driving survey effort from 2019 to 2021. The majority of our observations were recreational shooting groups, both overall and during each month of the study (80.38%; Figure 1.4). Target shooting made up 68.91% of recreation observations, followed by hunting

(11.47%), motorized recreation (8.11%), other (6.56%), and non-motorized (4.95%). Within observations categorized as "other," collecting brass and camping were the most common activities.

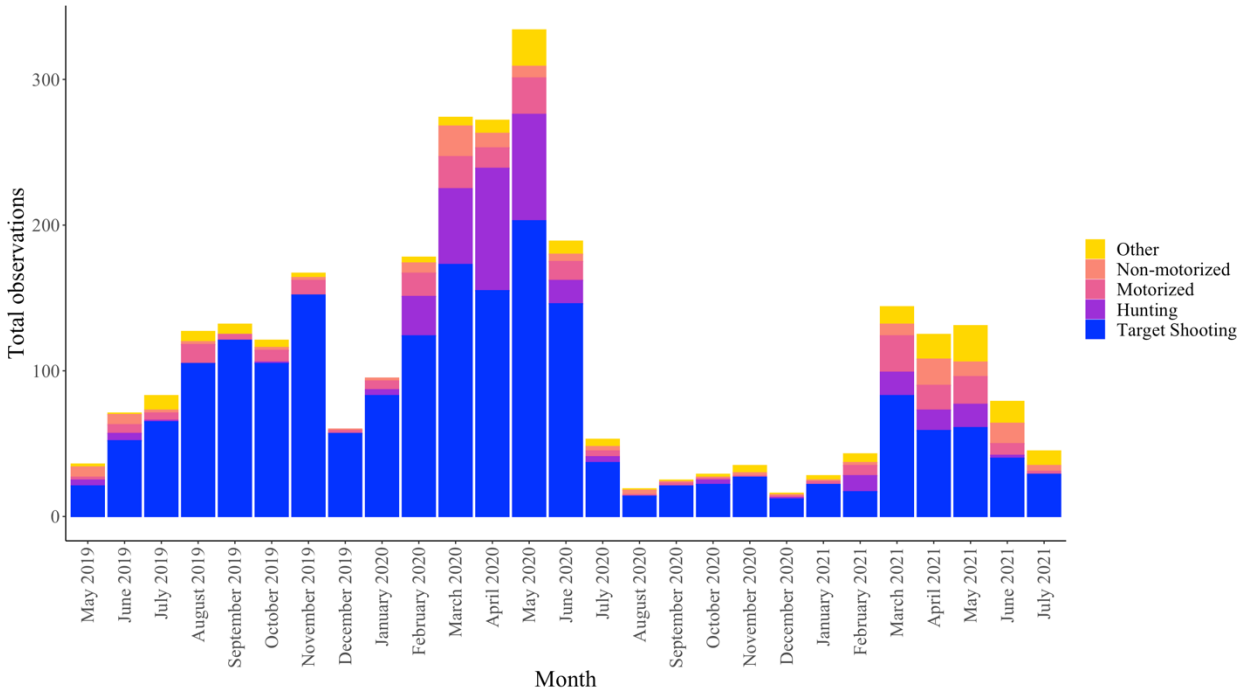

Figure 1.4. The proportion of recreational use classified as recreational shooting (target shooting or hunting ground squirrels) during each month of the study at the Morley Nelson Snake River Birds of Prey National Conservation Area in southwestern Idaho from 15 May 2019 to 17 July 2021. Survey effort varied across the months of the study, so this figure should not be used to assess trends in total use.

During driving surveys, we observed groups of 1 to 25 people, with a mean of 2.68 (± 1.90) per recreation group (Table 1.4). Over 87% of groups where demographics were obtained had at least one man, and 100% of recreational shooting groups had at least one man. Recreational shooting groups rarely included women (17.82%) or children (9.99%), and, thought there was not a striking contrast, other recreation groups more commonly had at least one woman (25.00%) or child (11.76%) present.

Table 1.4. Observed characteristics of recreational users during all driving survey routes at the Morley Nelson Snake River Birds of Prey National Conservation Area in southwestern Idaho in 2019 to 2021. Demographics were not possible to obtain for all observed groups, and summary statistics are reported only for groups with demographic information.

Characteristic	All Recreation	Recreational Shooting	Other Recreation
Number of people	2.68 ± 1.90	2.73 ± 1.85	2.37 ± 2.19
Number of vehicles	1.45 ± 1.16	1.39 ± 0.98	1.69 ± 1.68
Percent of groups with men	87.56	100.00	80.59
Percent of groups with women	18.74	17.82	25.00
Percent of groups with children	10.22	9.99	11.76

Self-Reported Temporal Use

Survey respondents who participate in recreational shooting reported similar amounts of use throughout the year, while other recreationists reported the highest use in May through September (Figure 1.5). Across all days of the week, the highest proportion of recreational shooters reported going shooting on Saturday and Sunday, while a high portion of other recreationists reported recreating on Saturday, Sunday, and Monday. On-site interview participants mentioned that their schedule was typically dictated by days off work or free from other responsibilities. Those with an open schedule reported recreating during the week to avoid crowds when possible. There was high variation in reported use per month among recreation participants within both groups. Some on-site interview participants commented that they avoid hot or rainy weather and poor road conditions. Others said they recreate more often when ground squirrels are active above ground. Two participants mentioned that the price of ammunition affects their shooting schedule as they are unable to recreate when the cost is too high.

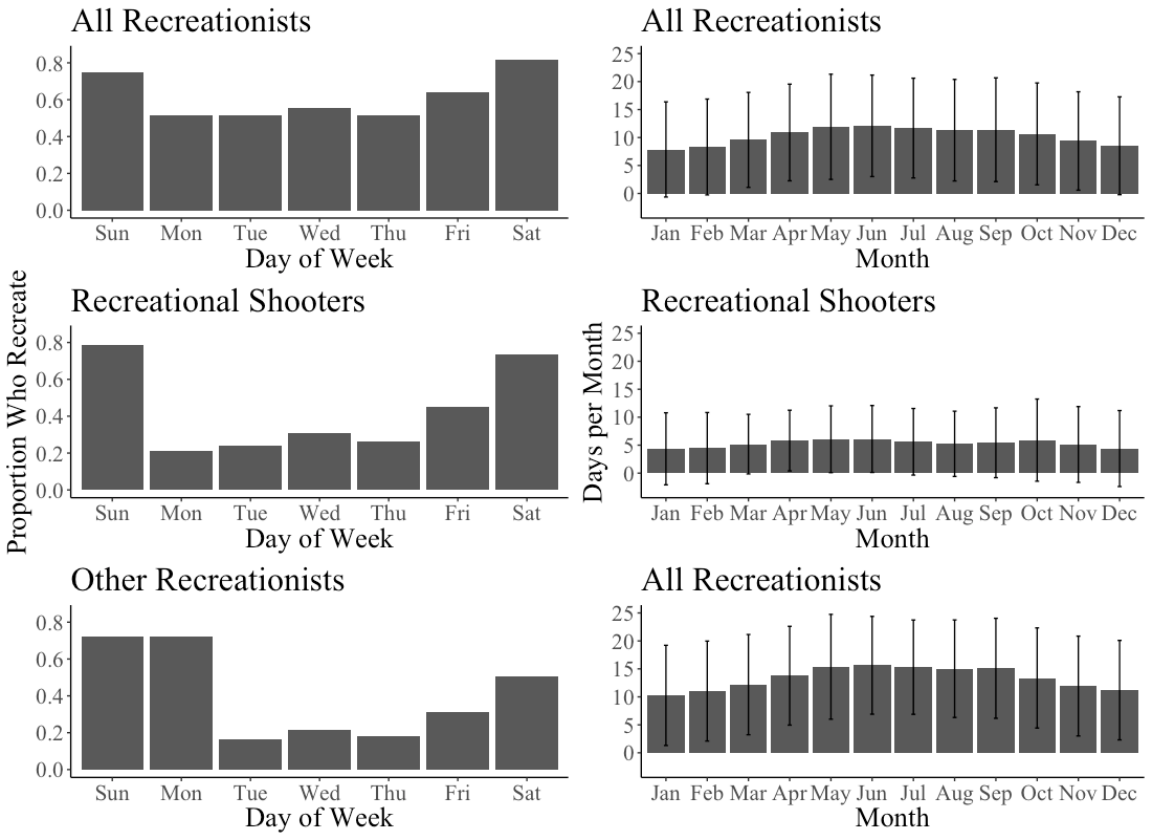

Figure 1.5. Reported temporal patterns of recreational use by survey participants in southwestern Idaho from April 2020 to July 2021. The proportion of all recreationists, recreational shooting participants, and other recreationists who report recreating on each day of the week is shown in Panel A. The number of days per month that survey respondents report recreating is shown in Panel B.

Self-Reported Site Preferences

Survey respondents who participate in recreational shooting ranked site section factors from 1 (most important) to 5 (least important; Table 1.5). Recreational shooting participants ranked backstops as the most important factor in selecting a site (TVF_m / n = 1.40), followed by the presence of other recreationists (TVF_m / n = 2.11). Vegetation type (TVF_m / n = 2.86), vantage points (TVF_m / n = 3.15), and ground squirrel abundance followed (TVF_m / n = 3.33). Online survey participants ranked the presence of other recreationists lower than on-site participants and more similarly to their rankings of vegetation type, vantage points, and ground squirrel abundance.

Table 1.5. Site selection factors ranked from 1 (most important) to 5 (least important) by survey respondents who participate in recreational shooting at the Morley Nelson Snake River Birds of Prey National Conservation Area. Lower TVFm and WCFm scores indicate more importance. The highest ranked factor in each row is bolded.

	Vegetation Type	Vantage Point	Backstop	Ground Squirrels	Other Recreationists
On-site Average (TVF_m / n)	3.50	3.22	**1.39**	3.70	1.89
Online Average (TVF_m / n)	2.74	2.42	**1.42**	2.89	2.37
Overall Average (TVF_m / n)	3.15	2.86	**1.40**	3.33	2.11
On-site Weighted Score WCF_m	0.70	0.64	**0.28**	0.74	0.38
Online Weighted Score WCF_m	0.57	0.48	**0.28**	0.58	0.47
Overall Weighted Score WCF_m	0.63	0.57	**0.28**	0.67	0.42

Online survey participants answered further questions to clarify their ranking order (Table 1.5), and on-site respondents sometimes offered comments. On-site participants noted that backstops were an important factor for safety, noting that a backstop is [paraphrased] *the first line of defense* and they [paraphrased] *want to know where the bullet is going*. One participant described an ideal backstop as [paraphrased] *a hill without a road on the other side, tall and wide enough to stop all shots or ricochets, close enough to the target that the bullet doesn't hit the ground and bounce up, and not made up of rocks*. Some participants were ambivalent about the presence of other recreationists, [paraphrased] *it's not super important, but I try to avoid crowds and shooting*; [paraphrased] *if someone gets there first, I'm okay setting up near people*, and [paraphrased] *everyone* [at the NCA] *is cool, but I prefer solitude*. Others mentioned changing their shooting location or the day of the week that they shoot to avoid crowding, and that they [paraphrased] *avoid* [other recreationists] *at all costs*.

Online survey participants rated sites far from recreationists (43 points) much higher than sites near other recreationists (12 points; Table 1.6). Ground squirrel abundance was not important to shooters who did not intend to shoot them, although some mentioned that they would shoot squirrels opportunistically. One described this as, [paraphrased] *if the ground squirrels are out, I will shoot them as a favor to the cattlemen, but it's not the driving force* [when selecting a site]. For people who wanted to shoot ground squirrels their presence ranked higher. One ground squirrel shooter described his "Three Squirrel Rule," where he looked through binoculars to assess a site and would only shoot there if he could see at least three ground squirrels at once through the binoculars. Online shooting participants ranked sites with open bare ground or short

vegetation as the most suitable (34 points), followed by sites that were rocky (20 points), recently burned (18 points), or shrub covered (16 points). Short vegetation was mentioned as beneficial for scouting for ground squirrels or avoiding rattlesnakes while moving through a site.

Recreational shooters typically reported having several sites that they would use (63%), while a smaller group had one preferred site they always use (11%). While most prioritized backstops and the presence of other recreationists, some had very specific requirements depending on the type of shooting they had planned that day. One participant described this, [paraphrased] *An ideal long-range shooting site would be on a hill for a vantage point with another hill at the other end of the range, around 1000 yards away. You want a clear area with no roads, divots, or canals to make it easier to carry the targets to the end of the range. For shooting with a pistol, an idea site would be a flat area with a good backstop. I also look for sites with no vegetation because I pick up brass*.

Table 1.6. Additional site selection questions asked of online survey respondents who participate in recreational shooting in southwestern Idaho (n = 19). For each characteristic, respondents were asked to rank a shooting site as not suitable (0), low suitability (1), moderate suitability (2), or high suitability (3). The total points given to each site type is reported.

Site Type	Total Points
Vegetation	
Open (bare ground, short vegetation)	34
Recently burned	18
Rocky	20
Shrub-covered	16
Other Recreationists	
Far from other recreationists	43
Near other recreationists	12

We asked all recreational shooting survey participants about factors that could prevent them from using their preferred sites (Table 1.7). The majority of participants indicated that other people using their preferred site had interfered with their use in the past (69%). Crowding near the preferred site was also listed as an interference by 60% of shooters and 70% of on-site survey participants. On-site survey participants mentioned that this was a safety concern because of the possibility of ricocheting bullets from nearby shooting groups. One stated that, [paraphrased] *you can't trust other people's gun safety*. The time it took to get to their preferred site was also a factor that prevented shooters from using their preferred site (38%). Being unable to access a site due to road conditions was less common (33%). On-site survey participants mentioned additional

factors, including military training exercises, trash, wildlife and cattle, and the cost of ammunition.

Table 1.7. Recreational shooting survey participants in southwestern Idaho were asked about factors that might prevent them from using their preferred site. The table shows the percent and number of participants who indicated that this interferes with their preferred site use (% (n)). Note that percentages may total over 100% because participants were able to select more than one factor.

What prevents you from shooting at your preferred site(s)?	Overall (n = 42)	On-site (n = 23)	Online (n = 19)
Time	38 (16)	39 (9)	37 (7)
Ability to access the site	33 (14)	43 (10)	21 (4)
People using your preferred site	69 (29)	83 (19)	53 (10)
Crowding near your preferred site	60 (25)	70 (16)	47 (9)

Effect of Recreational Shooter Characteristics and Motivations on Site Preferences

Recreational characteristics and motivations did not affect the rank of vantage points or backstops (Table 1.8). There was strong evidence that people who had been shooting longer ranked vegetation type as more important ($\beta = 1.11 \pm 0.04$, $P = 0.011$). There was weak evidence that people who were motivated by enjoying nature ranked vegetation type as more important ($\beta = 2.04 \pm 1.14$, $P = 0.073$), while people who were motivated by experiencing solitude ranked vegetation as less important ($\beta = -2.08 \pm 1.14$, $P = 0.067$). There was moderate evidence that ground squirrel hunters ($\beta = 2.92 \pm 1.55$, $P = 0.059$) and people who were motivated by viewing wildlife ($\beta = 2.34 \pm 1.19$, $P = 0.050$) ranked ground squirrel abundance as more important and weak evidence that people who took the survey online ranked ground squirrels as less important ($\beta = -2.09 \pm 1.19$, $P = 0.079$). There was moderate evidence that people with more shooting experience ranked

other recreationists as less important ($\beta = -0.08 \pm 0.04$, $P = 0.045$). All other effects were insignificant.

Table 1.8. Parameter estimates for ordered logistic regression models of the rank given to site selection factors by recreational shooters at the Morley Nelson Snake River Birds of Prey National Conservation Area.

Model Parameters	Odds Ratio	*ß*	*SE*	*T*	95% CI	*P*
Vegetation Rank Model						
Hunts ground squirrels	0.17	−1.77	1.18	−1.50	−4.15 to 0.51	0.134
Enjoying nature as top motivation	7.69	2.04	1.14	1.79	−0.13 to 4.39	0.073
Solitude as top motivation	0.13	−2.08	1.14	−1.83	−4.44 to 0.08	0.067
Socializing as top motivation	0.34	−1.07	0.77	−1.39	−2.64 to 0.93	0.165
Viewing wildlife as top motivation	2.58	0.95	1.07	0.89	−1.07 to 3.15	0.374
Years of shooting experience	1.11	0.10	0.04	2.56	0.03 to 0.18	0.011
Survey Format (online)	0.26	−1.37	0.99	−1.38	−3.36 to 0.58	0.168
Vantage Point Rank Model						
Hunts ground squirrels	0.53	−0.64	0.94	−0.68	−2.50 to 1.22	0.496
Enjoying nature as top motivation	0.64	−0.44	1.11	−0.40	−2.62 to 1.78	0.692
Solitude as top motivation	3.26	1.18	1.15	1.03	−1.12 to 3.51	0.304
Socializing as top motivation	1.65	0.50	0.71	0.71	−0.88 to 1.92	0.476

Viewing wildlife as top motivation	0.63	−0.46	0.99	−0.46	−2.43 to 1.53	0.645
Years of shooting experience	1.00	0.00	0.04	−0.05	−0.07 to 0.07	0.958
Survey Format (online)	2.94	1.08	1.22	0.88	−1.36 to 3.52	0.376
Backstop Rank Model*						
Hunts ground squirrels	0.49	−0.70	1.03	−0.68	−2.94 to 1.24	0.495
Years of shooting experience	0.98	−0.02	0.03	−0.60	−0.08 to 0.04	0.550
Survey Format (online)	0.84	−0.18	0.89	−0.20	−1.97 to 1.57	0.842
Ground Squirrel Density Rank Model						
Hunts ground squirrels	18.55	2.92	1.55	1.89	0.26 to 6.61	0.059
Enjoying nature as top motivation	0.65	−0.43	1.61	−0.27	−3.82 to 2.65	0.787
Solitude as top motivation	0.23	−1.48	1.33	−1.11	−4.39 to 0.97	0.266
Socializing as top motivation	2.49	0.91	0.88	1.04	−0.77 to 2.73	0.299
Viewing wildlife as top motivation	10.38	2.34	1.19	1.96	0.17 to 4.99	0.050
Years of shooting experience	1.05	0.05	0.04	1.27	−0.03 to 0.13	0.205
Survey Format (online)	0.12	−2.09	1.19	−1.76	−4.57 to 0.18	0.079

Other Recreationist Rank Model						
Hunts ground squirrels	2.62	0.96	0.98	0.99	−0.97 to 2.94	0.325
Enjoying nature as top motivation	0.67	−0.40	1.10	−0.36	−2.57 to 1.80	0.718
Solitude as top motivation	2.79	1.03	1.08	0.95	−1.09 to 3.20	0.340
Socializing as top motivation	2.34	−1.46	1.02	−1.42	−0.52 to 2.27	0.229
Viewing wildlife as top motivation	0.23	−1.46	1.02	−1.42	−3.57 to 0.49	0.155
Years of shooting experience	0.93	−0.08	0.04	−2.00	−0.16 to 0.00	0.045
Survey Format (online)	0.77	−0.26	1.00	−0.26	−2.24 to 1.74	0.794

* Predictors were removed from the backstop rank model because fitted probabilities that were numerically 0 or 1 occurred.

Observed Landscape Patterns of Site Use

Observed Temporal Patterns

While survey participants reported steady use throughout the year, our observed patterns of use varied through the year (Figure 1.6). High use was observed January through June, with a decrease in the hotter summer months of June and July, then a peak of recreational shooting in the fall during August, September, October, and November. Recreational shooting was the dominant type of use in the areas we surveyed throughout the entire year.

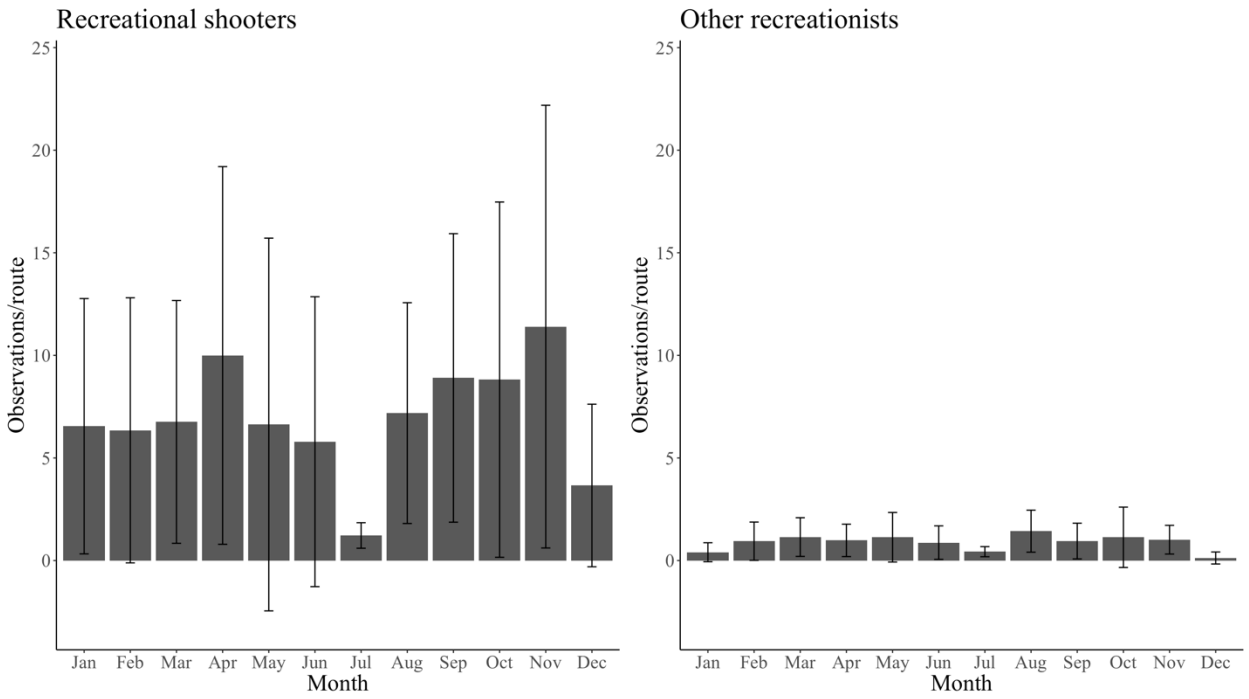

Figure 1.6. Observed patterns of temporal recreation use for all recreation, recreational shooting, and all other types of recreation at the Morley Nelson Snake River Birds of Prey National Conservation Area in southwestern Idaho from May 2019 to July 2021. Values are shown as mean recreationists observed per route (± SD).

Observed Spatial Patterns

When we examined the kernel density estimates for observed shooting and other recreation locations, we found that use was concentrated in the northcentral portion of the NCA and along the access road to the Snake River (Figure 1.7). Shooting use was particularly prominent in the north central area of the site and there was a smaller shooting hotspot off the Snake River access road. Other types of recreation were the most prominent along the road to the Snake River with a particularly intense spot at a short hiking trail to an overlook over the canyon.

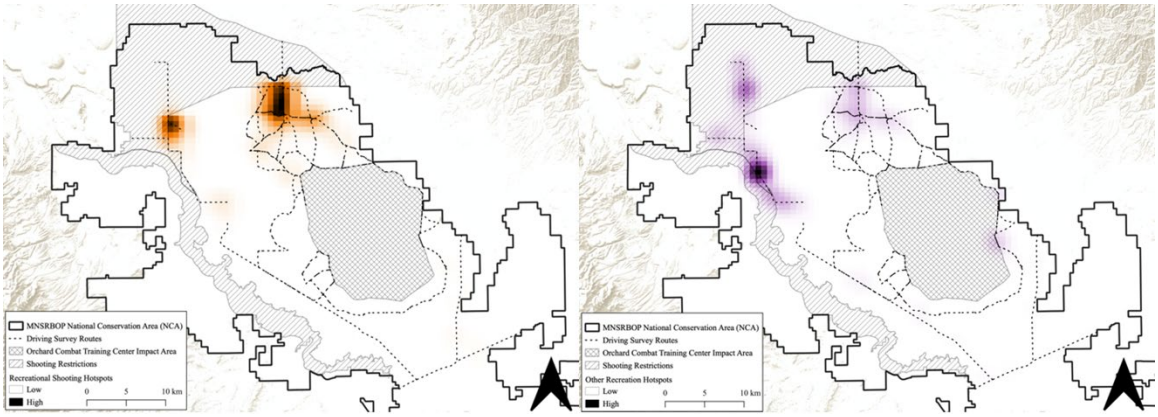

Figure 1.7. Hotspots for recreational shooting and other types of recreation at the Morley Nelson Snake River Birds of Prey National Conservation Area in southwestern Idaho from April 2019 to July 2021. The lowest values are shown in white and the highest are the darkest in color. Hotspot maps were created using all driving routes.

Recreation groups were typically observed in areas without any shrub cover (76.30%), followed by areas with big sagebrush (18.26%; Table 1.9). The majority of recreation groups were observed in areas with exotic annual vegetation (81.25% of all observations, 91.40% of recreational shooting observations), which included all invasive species except cheat grass. Non-shooting recreation groups were observed in exotic

annual vegetation less frequently (40.30%) and were also observed more often in perennial grasses (21.64%) and bare ground (13.06%).

Table 1.9. Observed habitat use of recreational users during our driving survey routes at the Morley Nelson Snake River Birds of Prey National Conservation Area from May 2019 to July 2021.

Characteristic	All Recreation	Recreational Shooting	Other Recreation
Overstory (%)			
Big Sagebrush	18.26	15.86	27.99
Forage kochia	0.05	0.05	0.00
Rabbitbrush	5.10	5.90	1.87
Winterfat	0.22	0.05	0.92
None	76.30	78.05	69.22
Unknown	0.07	0.09	0.00
Understory			
Bare	5.47	3.93	13.06
Cheatgrass	0.48	0.46	0.56
Exotic Annual Vegetation	81.25	91.40	40.30
Native Perennial Grasses	5.48	1.48	21.64
Sandberg bluegrass	0.15	0.09	0.37
Road	6.78	2.59	23.69
Rocks	0.07	0.00	0.37
Unknown	0.04	0.05	0.00

Model of Observed Use

We analyzed observations of recreational shooters (which made up over 80% of all observations, n = 2288), including people who were target shooting or hunting ground squirrels and other unprotected species. We observed 0 to 37 groups of recreational shooters along each survey. At the mean value of all covariates, the estimated number of

recreational shooting groups observed during a survey was 0.02 ± 1.63 groups (μ_{date} = June 9th, μ_{time} = 12:44 pm, μ_{temp} = 16 °C, weekday, pre-COVID). Recreation observations decreased throughout the year, increased throughout the day, and increased in warmer temperatures but not the hottest temperatures (Table 1.10). Greater numbers of recreational shooting groups were observed on the weekends. There was a significant positive relationship between the Stay Home Order and the number of recreational shooting groups observed, but recreational shooting did not differ significantly from pre-COVID levels after the Stay Home Order ended (Figure 1.4). The variance explained by route had strong support in the model (σ_{Route} = 2.75 ± 1.66). Routes with highest baseline number of shooting groups were in the northeast portion of the site (β_{A-5} = 2.59, β_{A-6} = 1.45, $\beta_{B-Northern}$ = 1.13) and along the road that leads to an access point for the Snake River (β_{A-9} = 1.79, β_{A-10} = 0.73).

Table 1.10. Parameter estimates for the number of recreational shooting observations at the Morley Nelson Snake River Birds of Prey National Conservation Area from April 2019 to July 2021. Observations were modeled using a Poisson generalized linear model with all model parameters scaled by two standard deviations.

Model Parameters	*ß*	*SE*	*Z*	Variance	*P*
Intercept	−4.04	0.49	−8.26		< 0.001
Day of Year	−0.12	0.04	−2.66		0.008
Time	0.16	0.04	4.09		< 0.001
Temperature (°C)	0.14	0.05	3.09		0.002
Weekend	0.96	0.06	15.47		< 0.001
Stay Home Order	0.54	0.07	7.97		<0.001
After Stay Home Order	0.03	0.05	0.62		0.538
Route Random Intercept				2.75 ± 1.66	
Subset A – 1	−1.13				
Subset A – 2	−2.52				
Subset A – 3	−1.71				
Subset A – 4	−1.99				
Subset A – 5	2.59				
Subset A – 6	1.45				
Subset A – 7	0.87				
Subset A – 8	−1.24				
Subset A – 9	1.79				
Subset A – 10	0.73				
Subset B – Northern	1.13				
Subset B – Southern	0.38				

We analyzed non-shooting recreation observations (n = 556). The estimated number of recreationists per survey at the mean value of all covariates was 0.01 ± 1.53 groups (μ_{date} = June 9th, μ_{time} = 12:44 pm, μ_{temp} = 16 °C, weekday, pre-COVID). Non-shooting recreation declined greatly with later dates in the year, increased with time of day, and did not have a significant relationship with temperature (Table 1.11). Weekends had a strong positive effect. Other types of recreation did not increase significantly during the Stay Home Order but were higher after the Stay Home Order ended than pre-pandemic. The variance explained by route was lower than for recreational shooters but still significant (σ_{Route} = 1.66 ± 1.29). The routes with higher baseline numbers of non-shooting recreation groups were similar to the other models, with routes in the northeast (β_{A-5} = 1.58, β_{A-6} = 0.25) and along the Snake River access road (β_{A-9} = 1.65, β_{A-10} = 2.41). There was an additional route along the southern portion of the NCA (β_{A-4} = 0.72) where there were concentrated OHV use areas.

Table 1.11. Parameter estimates for the number of non-shooting observations at the Morley Nelson Snake River Birds of Prey National Conservation Area from April 2019 to July 2021. Observations were modeled using a Poisson generalized linear model with all model parameters scaled by two standard deviations.

Model Parameters	*β*	*SE*	*Z*	Variance	*P*
Intercept	−5.18	0.42	−12.24		< 0.001
Day of Year	−0.46	0.10	−4.40		< 0.001
Time	0.17	0.08	2.13		0.033
Temperature (°C)	0.15	0.10	1.47		0.140
Weekend	0.92	0.18	5.05		<0.001
Stay Home Order	0.29	0.17	1.71		0.087
After Say Home Order	0.33	0.11	3.15		0.002
Route Random Intercept				1.66 ± 1.29	
Subset A – 1	−0.81				
Subset A – 2	−0.55				
Subset A – 3	−1.27				
Subset A – 4	0.72				
Subset A – 5	1.58				
Subset A – 6	0.25				
Subset A – 7	−0.79				
Subset A – 8	−1.80				
Subset A – 9	1.65				
Subset A – 10	2.41				
Subset B – Northern	−0.02				
Subset B – Southern	−0.89				

Comparison of Recreational Shooting and Other Recreation

There was little overlap between hotspots for recreational shooting and hotspots for other types of recreation (Figure 1.8). Recreational shooting was concentrated in the northern portion of the site and along the side roads off the route to the Snake River. Other types of recreation were clustered mainly along the access road to the Snake River where there are hiking trails and scenic overlooks. A lesser hotspot for non-shooting recreation in the eastern portion of the site was driven by OHV use and wildlife viewing, specifically birdwatchers observing burrowing owls (*Athene cunicularia*).

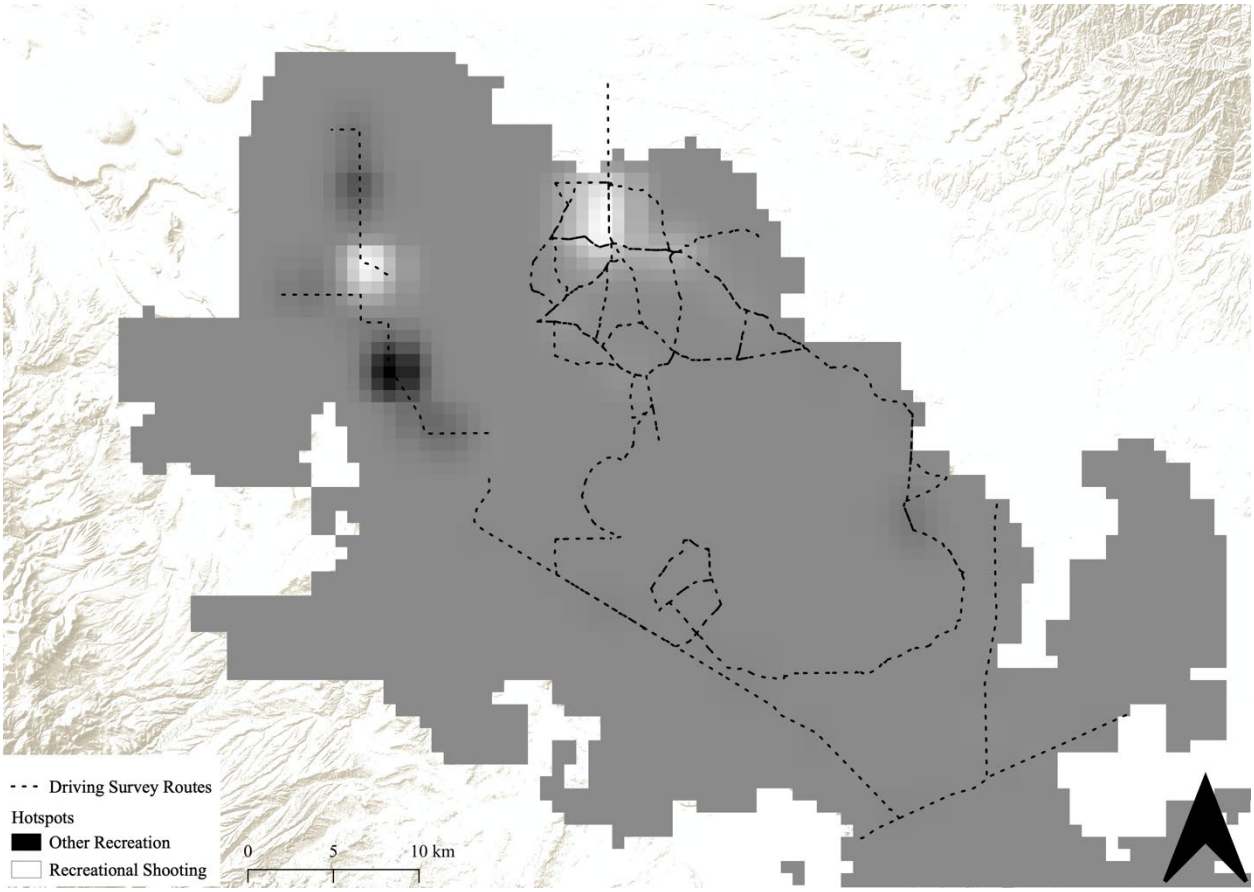

Figure 1.8. Differences in spatial patterns of observed recreational shooting and other types of recreational activities at the Morley Nelson Snake River Birds of Prey National Conservation Area in southwestern Idaho from April 2019 to July 2021. White areas are recreational shooting hotspots, areas that are shared or did not have recreation observations are gray, and black areas are hotspots of other types of recreation.

Comparison of Expected and Observed Patterns of Recreational Shooting

The Pauli et al. (2019) Map of Expected Use

We compared observed spatial patterns of recreational shooting use to predictions from a habitat suitability model that accounted for distance to major and minor urban areas, distance to a road, vegetation type, and elevation (Pauli et al. 2019; Figure 1.9). Relative to our observations, the Pauli et al. (2019) map over-predicted shooting use in the northern portions of the site and along major roads further into the site. The map under-predicted recreational shooting use in specific hotspots off the main access roads.

The same patterns of mismatch were seen in a comparison of the Pauli et al. (2019) map and a subset of observations from February and March (Appendix A).

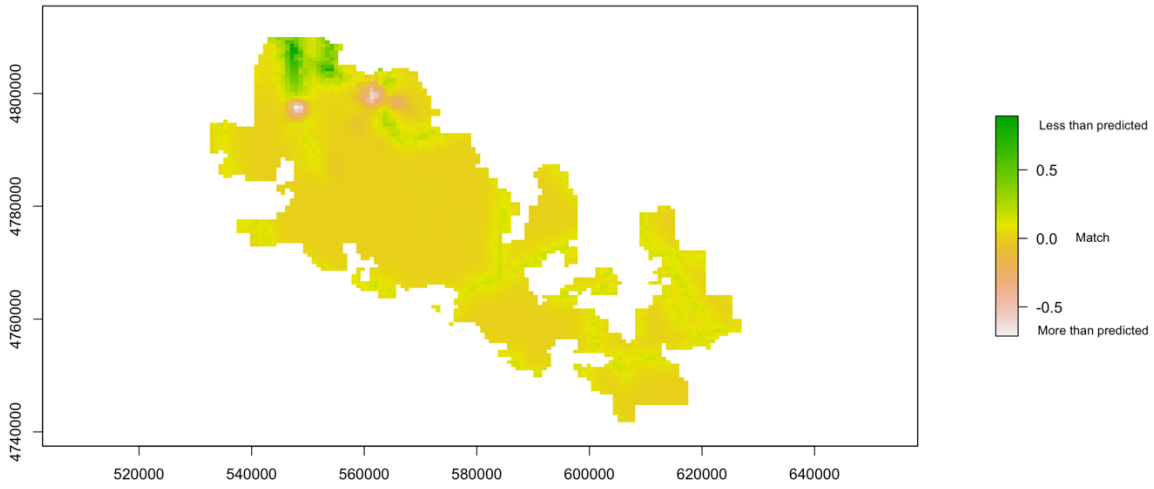

Figure 1.9. Differences in spatial patterns for expected and observed recreational where expected values come from the Pauli et al. 2019 map of expected use. Higher values (dark green) are areas with expected recreational shooting hotspots that were not observed, areas where predicted values match observed are close to zero (yellow/orange), and lower values are observed hotspots in areas that were not predicted (red/white).

Self-Reported Preferences Map of Expected Use

We compared observed patterns of use to the self-reported preferences map of expected use based on reported preferences for available backstops, vantage points, and vegetation type (Figure 1.10). We did not include the presence of other recreationists or ground squirrel abundance, which change over time. Our map of expected use over-predicted recreation in areas with suitable habitat and landscape features the southern portions of the site further from the Boise Metropolitan Area. The self-reported preferences map under-predicted use at heavily used areas near the entrance of the site.

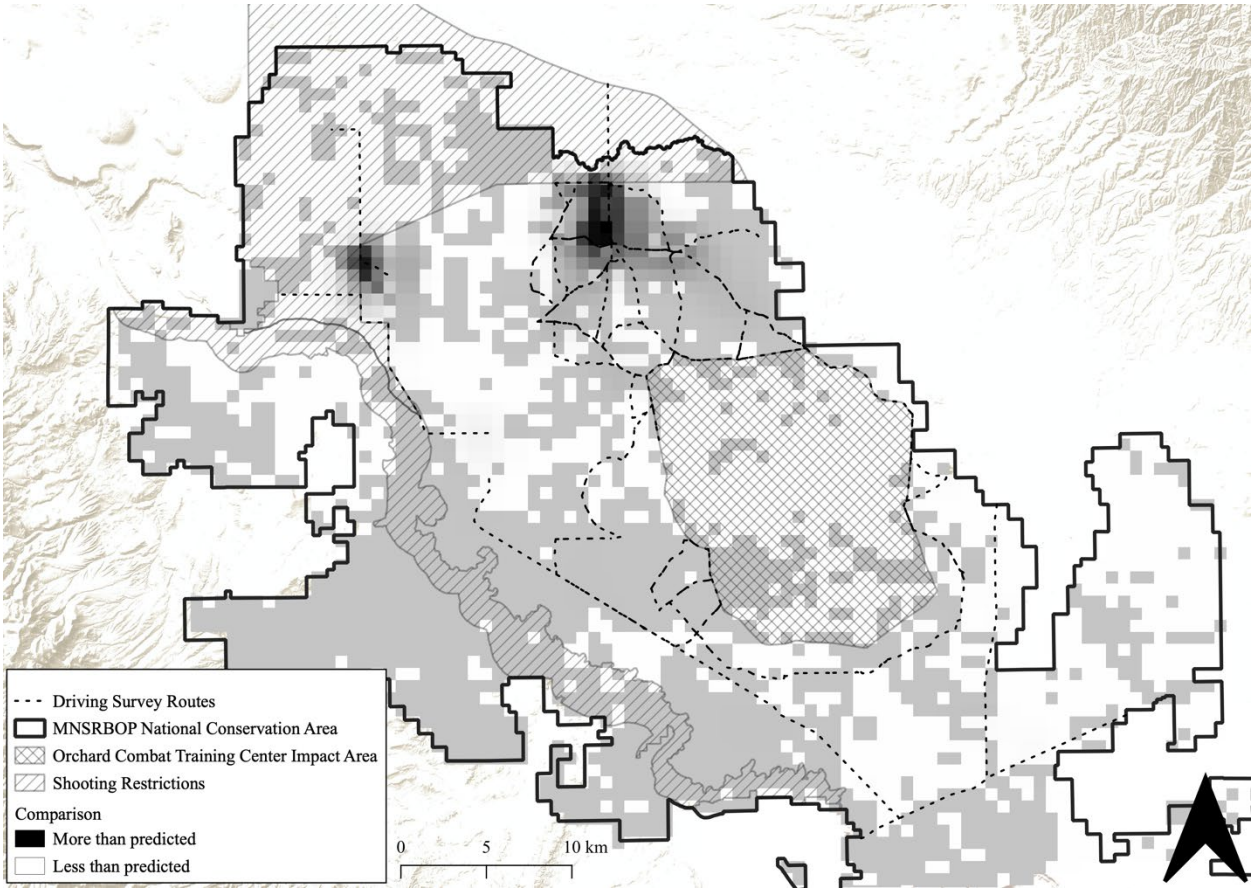

Figure 1.10. Differences in spatial patterns for observed patterns of use and expected use based on reported preferences by recreational shooters at the Morley Nelson Snake River Birds of Prey National Conservation Area in southwest Idaho. Black areas had higher than expected amounts of recreational shooting use, grey areas match predicted use, and white areas had less than expected amounts of use.

Discussion

Our results suggest that recreational shooters at the NCA selected sites based on safety and convenience, using sites with natural backstops and avoiding areas that are crowded with other recreational shooters. Site preferences among recreational shooters for vegetation, ground squirrel abundance, and the presence of other recreationists were affected by activity type, motivation, and years of experience. Recreationists concentrated in the northern portions of the site, which are closest to the Boise metropolitan area where most survey respondents reported living. However, there was

not a high degree of overlap between hotspots for recreational shooting and other use types, which was primarily observed along the river, canyon, and several areas with concentrated OHV trails. Reported temporal patterns in use did not match observed patterns, which peaked in the spring and early summer for all recreation and again in the fall for recreational shooting only. Models of our recreational observations suggested use was highest on weekends, earlier in the year, at later times of day, and in warmer temperatures but not the hottest temperatures. The effect of the COVID-19 pandemic on use varied by use type, with recreational shooting observations increasing during the Stay Home Order in Idaho and other types of recreation increasing after the Stay Home Order ended relative to pre-pandemic levels.

Effect of Recreational Shooter Characteristics on Site Preferences

Recreational shooters at the NCA prefer sites with lower vegetation, available vantage points and backstops, abundant ground squirrels, and less crowding. The presence of natural backstops and avoiding other recreationists were consistently the top two site selection factors reported by recreational shooters. In our driving surveys, we saw that recreational shooters commonly use sites with a natural backstop, such as a hill or rocky outcropping. However, many frequently used natural backstops are low or rolling hills that do not consistently stop bullets or rocky outcroppings that cause bullets to ricochet, making them less effective as safety measures. The importance of avoiding other recreationists varied among recreational shooters with some seeking out others, some being ambivalent, and others recreating at particular times or locations to avoid other recreationists. Vegetation type was less important, but recreational shooters report

preferring low vegetation. This matches observations of shooters in habitat consisting primarily of low exotic annual vegetation or bare ground.

We expected that years of shooting experience, participation in hunting ground squirrels, and high motivations to enjoy nature, find solitude, spend time with friends and family, and view wildlife would affect site preferences. We found that recreational shooters who were motivated to experience solitude ranked vegetation type as less important, while shooters with more experience and those who were motivated to enjoy nature reported that vegetation type was more important in selecting a site. The connection between enjoying nature and prioritizing vegetation at a site may be due to shooters looking for more aesthetic or natural sites (Opdahl et al. 2021). More experienced or specialized users in other systems tend to have more specific habitat requirements (Bryan 1977). We also found that recreational shooters who hunt ground squirrels or are motivated to view wildlife ranked the abundance of ground squirrels at a site as more important, while shooters who took the survey online reported that ground squirrels were less important. Ground squirrels are essential to this type of hunting and are a common wildlife species that can be viewed at the site. Lastly, we found that more experienced recreational shooters placed less importance on the presence of other recreationists, possibly because their familiarity with the area helped them feel more comfortable regardless of crowding levels. The relationships between recreationist characteristics and site preferences are consistent with other study results showing that more experienced users have different spatial patterns of use than less experienced users (Frey et al. 2018, Baker et al. 2021) and that the reported motivations of recreationists affect their site preferences and how they move through an area (Opdahl 2018, Frey et al.

2018, Sisneros-Kidd et al. 2021, Baker et al. 2021). In our study, survey respondents generally ranked site selection factors in the same way. This could be because site selection is consistent among recreational shooters or could be due to our sample missing a portion of the user group that selects sites differently. Because our sample is most likely biased toward more invested and experienced users, the missing perspective would most likely be new and inexperienced recreational shooters.

Our survey respondents were primarily male and residents of the surrounding Boise metropolitan area. Though our intention was to represent the full spectrum of users at the NCA, and the proportions in our on-site and online samples were similar, our survey sample may have been biased. The true demographics of the population of recreationists at the NCA is unknown, but we consider potential biases as we examine our results. On-site sampling required respondents to stop voluntarily, which limits the sample to people who have time, feel safe stopping, and have some degree of trust for the institution conducting the survey (Vaske 2008). Our survey sample was primarily male, particularly the sample of recreational shooters, but this is consistent with the high percentage of observed shooting groups with men. Our on-site survey only included one non-shooting recreationist due to the high proportion of recreational shooting in the area where we surveyed. Our online survey sample relied on membership in a recreation-based group, which could have biased the survey sample toward older, more experienced or serious recreationists. Our results do not represent the more varied recreational user groups using the Snake River Canyon (Bill Dyke, Idaho Power, personal communication), which was outside of the scope of this study.

Spatiotemporal Patterns of Recreational Use

We observed more recreationists using the NCA on weekends, earlier in the year, later in the day, and on warmer days. Less users at later dates are consistent with recreationists using the site while ground squirrels are active above ground in mid-January to mid-June (Steenhof et al. 2006) and road and weather conditions are more optimal. More recreationists were observed in warmer temperatures, but recreation decreased at the hottest temperatures. This is consistent with other studies that suggest there is a limit to the temperatures that recreationists are willing to tolerate, which could change patterns and timing of recreational use throughout the year (Wilkins et al. 2021). In warm, dry areas like the NCA, higher temperatures are expected to shift recreational use earlier into the spring. This is already a popular time for shooting at the NCA, so an increase of other users could increase conflicts and impacts during an already crowded and ecologically important time. Observed temporal trends did not match self-reported trends, which could be due to inaccuracies in reporting behavior (Borrie 1998, Vaske 2008) or factors that prevent recreationists from recreating at their ideal frequency. Factors reported by recreationists included the cost of ammunition, rainy weather, bad roads, and work or other time commitments.

Recreation trends on public lands are affected by external events. The COVID-19 pandemic began one year into our study and affected recreational use at the NCA. We observed an increase in recreational shooting during the Stay Home order, which was in effect in Idaho from 25 March to 30 April 2020, relative to use prior to the pandemic. However, recreational shooting observations after the Stay Home order ended were not significantly higher than pre-pandemic levels. Conversely, other types of recreation did

not increase during the Stay Home Order but were significantly higher than pre-pandemic levels after the Stay Home Order ended. Other public lands near urban areas experienced increased use during the COVID-19 pandemic as people stayed closer to home to recreate and more popular recreation areas, such as national parks, closed or dramatically reduced use (Hockings et al. 2020, Rice and Pan 2021, Spenceley et al. 2021, Geng et al. 2021). Closures of shooting ranges during the Stay Home Order could account for some of the increased shooting use during that period, while national and state park use remained restricted further into the post-Stay Home Order period. During this time, we observed more non-shooting recreationists, particularly dispersed camping at the NCA.

Comparison of Recreational Shooting and Other Recreation

As we predicted, there was little overlap between recreational shooting and other types of recreational use at the NCA. This may be due to the specific needs of different activity types, such as recreational shooters looking for natural backstops or hikers using a hiking trail in a more scenic area. Because we only asked recreational shooters about their site preferences, we do not have information on how other recreationists choose sites at the NCA. The separation of use types could also be due to recreationists avoiding other types of users, which a number report trying to do.

Comparison of Observed and Expected Recreational Shooting

In addition to describing and assessing recreational use, we compared two methods of assessing recreational shooting use that did not require a high degree of participation from the user group. The first was a map of habitat suitability for recreational shooting created with a MaxEnt presence-only model of recreational shooting at the NCA that accounted for distance to major and minor urban areas, distance

to access roads, elevation, and vegetation type (Pauli et al. 2019). The second was a self-reported preferences map of expected use we created using recreational shooters' self-reported preferences for natural backstops, vegetation type, and vantage points following a method used by Gül et al. (2006). In a comparison of observed use and predictions by the Pauli et al. (2019) habitat suitability map, we found that recreational use was over-predicted in the most northern portions of the site and along main roads further into the site. The map of expected use based on reported preferences also over-predicted recreational shooting further into the NCA. Parts of the northern NCA are restricted to shooting use, which may have caused some of the differences in observed and expected use in those areas. Suitable sites along main roads further into the NCA that had less observed use than expected would be consistent with survey participants who report that time and road accessibility affect their ability to recreate at preferred sites to some extent. It is also possible that most recreationists are traveling to the site from the Boise metropolitan area and stop at the first suitable site they come across, which has been observed in other systems (Drage et al. 2020, Creany et al. 2021). Both maps of expected use under-predicted shooting in two specific hotspots that were located on side roads adjacent to the main access roads. Part of this may be due to the Pauli et al. (2019) model not including specific topographic features, such as natural backstops, that shooters prioritize when selecting a site. Aside from areas where shooting is restricted, sites that were predicted to be highly suitable but received lower use tended to be further into the NCA and further from home for most recreationists. These areas may be places to watch for an increase in use if an increasing number of recreational shooters begin to go further into the site to avoid crowds.

A factor that may make it difficult to predict site use at the NCA is the lack of formal cues about where and how to recreate. In a recreation area with more infrastructure, cues would include trails and signs. At sites with lower recreation infrastructure, recreationists use other types of affordances (D'Antonio and Monz 2016) and social cues may be particularly important (Li 2013). At the NCA, affordances could include locations of other recreationists and shooting debris that indicates a site has been used. These factors may contribute to the high use shown in the northeastern portion of the site even though there are suitable sites further into the NCA. The western portion of the NCA along the Snake River has signs and established recreation areas and trails, which may help to direct and concentrate use, particularly for types of recreationists other than recreational shooting (D'Antonio et al. 2013).

Recreational use, particularly recreational shooting use, at the NCA showed a high amount of variation over space and time throughout the duration of the study and was affected by date, time of day, temperature, day of the week, and external events such as the COVID-19 pandemic. Recreationist site choice is part of a dynamic and adapting social-ecological system and varies greatly as a result (Morse 2020, Miller et al. 2021). Understanding patterns of recreational use and site choice in this low-infrastructure system can help us to better manage the increasing pressure on public lands spurred on by human population growth and the increasing popularity of many types of outdoor recreation (Braunisch et al. 2011, D'Antonio et al. 2016). Recreational use is separated by activity type, which may help to prevent some amount of conflict. Current recreational use is concentrated in the northern portion of the NCA but may spread into areas that are predicted to be suitable but are not currently used. We recommend that levels of overlap

of use and spread into the site should continue to be monitored as use increases. Recreational shooters generally look for sites with backstops, but many of the backstops used are too low or rocky to be effective and keep nearby users safe. It may be helpful to provide reminders or tips for finding a safe shooting site or to put notices in commonly used areas with ineffective backstops. Backstops in high use areas could also be improved or added to provide more safe spots for shooting. Adding affordances, such as signs, clear shooting spots, or trails, could help to direct use to more suitable areas. These efforts can help to provides for enjoyable recreation experiences and the preservation of the ecological system.

CHAPTER TWO: PERCEPTIONS OF RECREATION IMPACTS, CHALLENGES, AND MANAGEMENT AMONG OUTDOOR RECREATIONISTS, MANAGERS, AND BIOLOGISTS

Abstract

Increased recreational use on public lands leads to the possibility of negative impacts to the recreation experience and the conservation of natural resources. We assessed how recreationists, managers, and biologists perceive impacts on, challenges to, and management of recreation at a National Conservation Area (NCA) in southwest Idaho. Our goal was to understand the perceptions of key social groups and explore opportunities to reduce recreation impacts. Recreationists included recreational shooters, who shoot targets or unprotected species and are the largest user group at the site, and birdwatchers, whose activity is dependent on the natural resources at the NCA. We surveyed recreationists using on-site interviews and online surveys distributed to recreation-based organizations. We also interviewed managers and biologists associated with the NCA. Surveys included questions about concerns, perceptions of recreation impacts, and views on management. To assess the limits of acceptable impacts among groups, we assessed the acceptability of three levels of trash and crowding that represent conditions at the NCA, then compared ratings of acceptability between groups accounting for years of experience using an ordered logistic regression model. Recreational shooters were primarily concerned with trash, crowding, and safety, while managers and biologists listed a variety of concerns focused on wildlife, habitat, safety, illegal killing of protected

wildlife, lead, and trash. Compared to other social groups, recreational shooters rated low and medium trash conditions as more acceptable. Conversely, recreational shooters rated all crowding conditions as less acceptable than did the other groups. Recreational shooters and birdwatchers placed the highest responsibility for enforcing rules on individuals and law enforcement but differed in their perspectives of the role of management agencies. Recreational shooters were supportive of educational management interventions, birdwatchers supported management changes and recreation participation, and both groups did not support limiting use. Managers and biologists suggested a variety of management actions, including various types of spatial and temporal closures, increased law enforcement, and designated shooting areas. We use the results to identify opportunities for improving recreation at the NCA. Our results highlight the importance of considering multiple recreational user groups along with managers and biologists.

Management Implications

- Education efforts to increase awareness of environmental impacts and species of concern may be effective and well-received by recreationists.
- Positive recreation behaviors may be promoted using opinion leaders and other social influences to make emotional appeals for appropriate behaviors and advertise that desired behaviors are the norm within recreation groups.
- With many new users at the site, it is important to distribute information in locations that are likely to be seen by all recreationists, such as sporting goods stores or ahead of turnoffs into the site.

- Widespread closures or limits to site use are likely to be met with resistance by recreationists but creating designated areas for shooting may be a viable option for indirectly concentrating shooting use at the site.

Introduction

Since the 1970s outdoor recreation has grown rapidly across the United States (Sumanapala and Wolf 2019). During the same period, there has been a trend of people moving closer to recreational areas, particularly in the western United States (Hansen et al. 2002, Lybecker 2020). The increase in recreational use of public lands brings the potential for increased conflict among recreationists and between recreation and other uses of the site, including conservation. Conflict among recreationists may arise from direct interactions, such as competition for sites or unwanted behaviors. Indirect interactions, such as impacts to a recreational site that negatively affect the quality of other visitors' experiences, may also cause conflict (Lynn and Brown 2003). Conflicts may occur within user groups but are more likely to occur across user groups with different activities, motivations, and social norms (Confer et al. 2011, Happ and Schnitzer 2022). In addition to conflict within and between recreation groups, recreation may have negative impacts on other types of use at a site or the natural resources within an area. Natural resource impacts include habitat degradation and wildlife disturbance or displacement, which can lead to population or community impacts over time (Larson et al. 2016, Sumanapala and Wolf 2019). Land and wildlife managers in these complex and increasingly utilized systems must consider social and environmental conflicts of recreation for the long-term sustainability of the system (Morse 2020, Miller et al. 2021, McCool 2022).

To manage recreation and conservation on public lands, it is necessary to understand for the perspectives of social groups within the system. To be effective in understanding those perspectives, management agencies often determine the interests of user groups, weigh natural resource needs, and consider the long-term sustainability of the area for future generations (Brown et al. 2014). The support of user groups is necessary for successful management actions (Bright and Manfredo 2008, Metcalf et al. 2017, Thomsen et al. 2022). Support and behaviors are related to views of the acceptability of management actions or rules, which are linked to an individuals' attitudes and emotions. Attitudes and emotions fall within a cognitive hierarchy with a few core values that do not change frequently or have a direct effect on behavior to attitudes, emotions, and norms which are numerous, change often, and have an impact on behavior (Vaske and Donnelly 1999). Views of acceptability are related to an individual's knowledge and previous experiences, as well as the situation and time period (Thomsen et al. 2022). Asking social groups about their concerns, limits of acceptable recreation impacts (Stankey et al. 1985), and views of management can provide insight into the norms of each group, areas where conflict may arise, and reactions to potential management strategies (Vaske and Needham 2007).

One strategy for mitigating indirect conflicts between social groups at a site is to understand how much of an impact each group is willing to tolerate. This can be assessed using the Limits of Acceptable Change framework (Stankey et al. 1985), which has been applied to various recreational contexts to determine how much of an impact can be allowed before visitors are negatively impacted (Shelby and Shindler 1992, Needham and Rollins 2005, Hughes and Paveglio 2019). The minimum acceptable condition is referred

to as the standard of quality. The Limits of Acceptable Change framework identifies standards of quality for indicators, which are the variables that make up a recreational experience (Needham and Rollins 2005). Indicators can be related to management, social, or environmental factors, but should be specific, objective, measurable, manageable, and related to visitor use (Manning 2011). Indicators in past applications of the Limits of Acceptable Change framework include crowding and campsite impacts (Shelby and Shindler 1992, Needham and Rollins 2005, Hughes and Paveglio 2019). Individuals are asked to rate the acceptability of levels of an indicator to determine the standard of quality for a group (Needham and Rollins 2005). Acceptability is typically assessed using visual methods to standardize measurements (Manning and Freimund 2004, Needham and Rollins 2005).

Standards of quality are assigned using a normative approach to identify what a group believes is acceptable (Vaske et al. 1993, Needham and Rollins 2005). This approach focuses on social norms, which are held within a group and create an obligation among group members (Vaske 2008). Social norms can be descriptive or injunctive. Descriptive norms are the behaviors of others within a group, while injunctive norms are the levels of disapproval from the group regarding an undesirable behavior (Cialdini et al. 1990). Social norms, specifically injunctive norms, are a powerful tool for behavior change (Cialdini et al. 2006, Bernedo et al. 2014), as norms and attitudes are more flexible and have a greater effect on behavior (Vaske 2008). Within the Limits of Acceptability framework and other measures of social group agreement, the Potential for Conflict Index (PCI) is often used to show norm crystallization, or the amount of agreement within a group (Manfredo et al. 2003).

Key social groups in outdoor recreation systems include recreationists, managers, and biologists. Asking these groups about their concerns, limits of acceptable recreation impacts, and views of management can provide insight into the norms of each group, areas where conflict may arise, and reactions to potential management strategies. Despite evidence that views often differ between user groups (Shelby and Shindler 1992), few studies have examined the norms of multiple groups in the context of outdoor recreation (Needham and Rollins 2005). A recent review of recreation ecology literature found that we lack an understanding of how management actions will be received by the users of a site and the agencies implementing the action (Sumanapala and Wolf 2019). Including management agencies and biologists gives an understanding of the larger social context in which outdoor recreationists operate and helps to address this gap. Being able to compare the knowledge, concerns, limits of acceptable impact, and ideas of recreationists with those of managers and biologists can help identify challenges and opportunities for management.

Our study aimed to identify how the perceptions of recreationists, managers, and biologists differ at a National Conservation Area (NCA) in southwest Idaho. The closest portion of the NCA is 20 minutes from Boise, Idaho, USA, one of the fastest-growing population centers in the United States (U.S. Census Bureau 2020). The area is experiencing increased recreational use (Chapter 1), population declines of wildlife species (Rosenberg et al. 2019), and illegal killing of protected wildlife species (Katzner et al. 2020), all of which could put recreationists in conflict with each other, as well as biologists and managers. Our objectives were to 1) assess the concerns of each group regarding the impacts of recreation on the National Conservation Area, 2) define the

standards of quality for each group for two indicators (trash, crowding), 3) compare standards of quality between groups, 4) assess how knowledge and perceptions of management rules and actions differ between groups, and 5) use this information to identify opportunities for management to address impacts of concern.

Study Context

Our study was conducted the Morley Nelson Snake River Birds of Prey National Conservation Area (NCA; 484,873 acres), located approximately 30 km south of Boise, Idaho (Figure 1). The Bureau of Land Management (BLM) manages the NCA and jointly manages Department of Defense training center within the area, the Orchard Combat Training Center (OCTC), with the Idaho Army National Guard (IDARNG). The NCA was established in 1993 to preserve and protect the nesting and foraging habitat of one of the largest and densest population of nesting raptors known in North America (Public Law 103-64). The surrounding metropolitan area has experienced rapid growth since the 1990s (U.S. Census Bureau 2020), leading to a dramatic increase in the number of people using public lands, including the NCA (A. Hoffman, Bureau of Land Management NCA Manager; B. Flatter, Idaho Department of Fish and Game Law Enforcement Officer; C. Baun, Idaho Army National Guard Conservation Branch Manager; pers. comm., Chapter 1). Ecotypes at the NCA include a river canyon and extensive shrub-steppe and grassland areas that provide habitat for a variety of mammalian and avian species.

Multiple types of public recreation are practiced throughout the NCA, except within the areas used for military training exercises that are off limits for safety reasons (Impact Zone, see Figure 2.1). Recreational shooting of inanimate targets and unprotected mammals, most commonly Piute ground squirrels (*Urocitellus mollis*), is particularly

popular at the site and is estimated to draw thousands of visitors per week during the peak season (Chapter 1, Walter 2016). Recreationists appear to cluster near the northcentral entrance to the NCA (shooters, off-highway vehicles, dirt bikes) and along the Snake River canyon (shooters, off-highway vehicles, hikers, photographers, fishing, boating; Pauli et al. 2019; Chapter 1). The nesting raptors and other birds at the site attract birdwatchers who concentrate near the canyon but can also be found looking for specific species throughout other habitats in the NCA. The NCA also supports military training, cattle grazing, and research.

We focused on understanding recreational shooting because the growth in recreational shooting exceeds the growth seen in other metrics of recreation within the NCA, including a tripling of visitors to another BLM recreation site since 2011 (Bureau of Land Management, unpubl. data) and a doubling of visitors to a public shooting range since 2014 (Idaho Department of Fish and Game, unpubl. data). In addition to being the most prevalent type of recreation in the NCA, recreational shooting is associated with several potential management concerns including crowding, unsafe shooting, trash dumping for target use, wildlife disturbance, and scavenger supplementation. The activity also shows high overlap with instances of illegal killing of protected wildlife species in our study area (Katzner et al. 2020).

Key social groups in our analysis included recreational shooters, birdwatchers, biologists, and managers. We included birdwatching as another common type of recreation at the NCA that is likely to be more reliant on the natural resources at the site, specifically raptors and their habitat. We included management agencies that directly manage the NCA (BLM, IDARNG) as well as agencies with jurisdiction over the wildlife

(Idaho Department of Fish and Game, United States Fish and Wildlife Service) or utilities within the site (Idaho Power). We included biologists from academic institutions (Boise State University), government agencies (United States Geological Survey), and a non-profit organization (Intermountain Bird Observatory) whose research includes species or sites within the NCA.

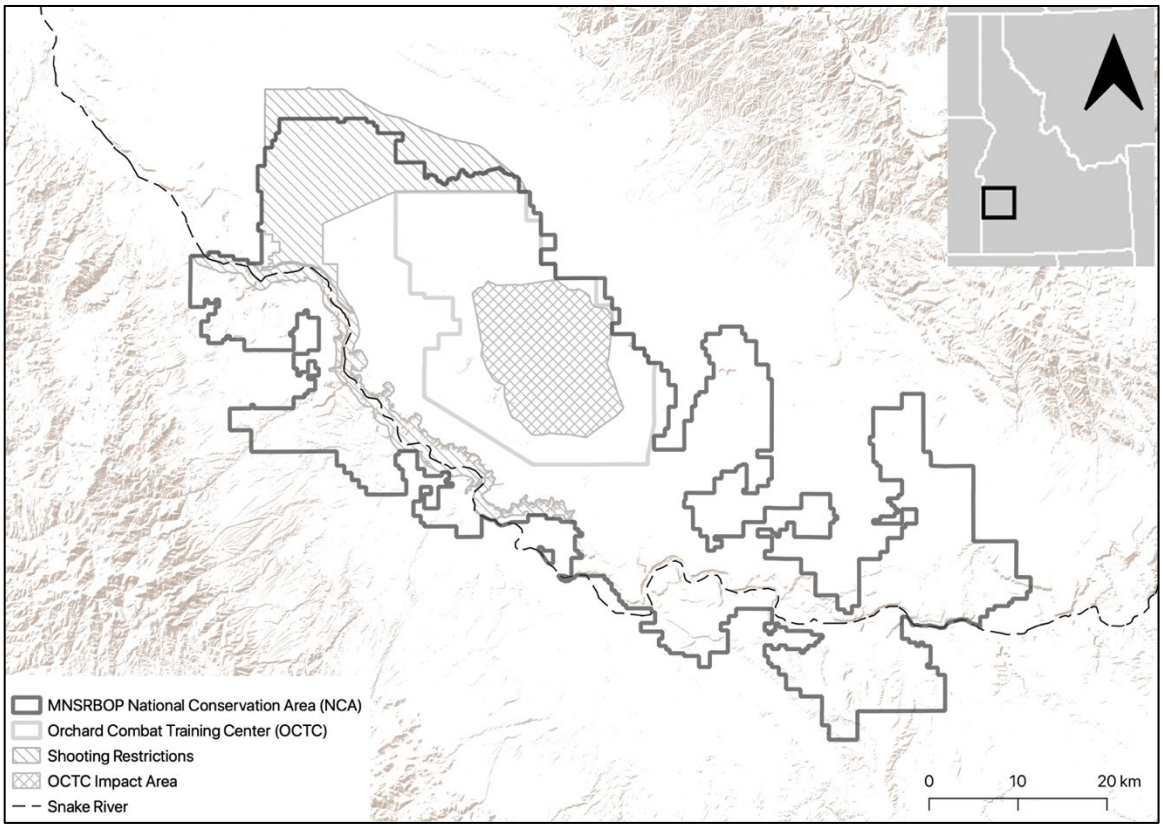

Figure 2.1. Map of the Morley Nelson Snake River Birds of Prey National Conservation Area (NCA) in southwestern Idaho, including land ownership and boundaries of various land managers within the NCA. The Orchard Combat Training Center Impact Area excludes any public access. Areas with shooting restrictions allow public access and other types of recreation.

Methods

Multi-modal Survey

We used a multi-modal survey effort with the goal of assessing the concerns, standards of quality, and perceptions of management actions for recreational shooters, birdwatchers, managers, and biologists. We used information gained during a pilot field season (April to August 2019; Appendix D) to design a questionnaire to understand concerns, perceptions of indicators, and standards of quality. We planned to use on-site interviews for the full survey effort to allow participants to expand on their answers and respond to open-ended questions. However, the COVID-19 Pandemic made on-site interviews difficult during the study, so we used an online survey to supplement our survey efforts. We incorporated close-ended questions, free listing, rank ordering, and paired comparisons (Bernard 2011).

We utilized visual methods to assess how individuals view impacts to the site (Manning and Freimund 2004), which involved presenting participants with images that varied in the indicator of interest, specifically crowding or litter at shooting site. This makes measurements more valid by standardizing how participants define an indicator (Manning and Freimund 2004). We used the TouchRetouch application (© ADVA Soft, Version 2.3.4) to alter the level of the indicator in the images. We included 3 levels of each indicator (trash, crowding), which are representative of conditions experienced by recreationists at the site (Figure 2.2). Because much of the NCA has dispersed use and dedicated trails primarily occur in and near the canyon, our crowding indicator was based on the number of groups and vehicles within an area rather than the number of people on

a trail, which is a commonly used metric. We presented the levels of each indicator to participants in a random order to avoid biasing acceptability ratings.

All survey procedures and questions were reviewed and approved by Boise State University's Institutional Review Board and NCA management agencies. All personnel completed the Collaborative Institutional Training Initiative (CITI) for Human Subject Research prior to surveying participants.

Figure 2.2. Photos shown to survey participants at the Morley Nelson Snake River Birds of Prey National Conservation Area and at associated management agencies and research institutions from April 2020 to November 2021. Panel A shows trash indicator photos from high (top), medium (middle), to low (bottom). Panel B shows crowding indicators from high (top), medium (middle), to low (bottom).

Online Surveys

We developed a sampling frame of recreation-based organizations in southwestern Idaho. From 17 April 2020 to 25 July 2021, we distributed the survey with Qualtrics software (Qualtrics, Provo, UT, USA). Because no comprehensive list of recreational shooters or birdwatchers exists, we sent the survey to a publicly listed contact person for each group who distributed the survey to their contact list. We emailed each contact person up to 3 times about distributing the survey. We also advertised the survey at sporting goods stores and indoor shooting ranges. Our online survey included questions about acceptable impacts, perceptions and knowledge of rules, and opinions about responsibility and management (Appendix E, F). Surveys distributed to recreational shooters included additional questions to address other study objectives (Chapter 1). We removed all participants who did not report using the NCA at least once per year.

On-site Interviews

Our on-site survey was a pared-down version of the online survey (Appendix G). We administered the survey to recreationists on-site at the NCA where we intercepted visitors along access roads from 13 March to 25 July 2021. We used a stratified random approach with two strata of days – weekdays and weekend/holidays – to select survey days. On selected days, we surveyed for 1 – 4 hours at a survey location along the NCA access roads (Appendix B). We placed signs along the road in either direction to advertise the study. When an individual or group stopped, we gave them a brief overview of the survey purpose and content, then asked one individual in the group to participate. We provided participants who did not have time to complete the survey on-site with instructions for accessing the online survey. We administered on-site surveys as an

interview, which enabled participants to provide additional details about their responses and answer open-ended questions. To allow an open discussion, we did not audio or video record interviews. Instead, the interviewer took written notes and documented responses.

Semi-structured Interviews with Key Personnel at Management Agencies and Research Institutions

We conducted semi-structured interviews with key informants from management agencies and research institutions whose work involves the NCA. This included the BLM, IDARNG, Idaho Department of Fish and Game (IDFG), United States Fish and Wildlife Service (USFWS), Boise State University (BSU), the Intermountain Bird Observatory (IBO), and the United States Geological Survey (USGS). We identified individuals with management or research relevance to the NCA through publicly available information and information gained during our pilot field season. We asked interviewees about their perceptions of recreationists at the NCA as well as other individuals they thought should be interviewed. We used this information to conduct a snowball sample of individuals until no new information was gained by additional interviews (Vaske 2008, Bernard 2011).

Our interview protocol was semi-structured, allowing us to modify questions as needed. We conducted interviews on Zoom (video conferencing; Zoom Video Communications, Qumu Corporation) from 15 September to 24 November 2021. We kept interviewees' identities anonymous and did not audio or video record. During the interview, the interviewer took written notes. Managers and researchers were instructed

to answer the questions from their professional perspective. Our interviews included structured questions and open-ended questions (Appendix H).

Analysis

We conducted our statistical analyses in R (R 4.1.2, RStudio 2022.02.0; R Core Team 2021). We analyzed quantitative survey responses using summary statistics and regression models. We used a frequentist framework in our analyses and considered α values less than or equal to 0.05 to be significant in regression models. We classified open-ended interview responses into discrete or categorical variables, which were summarized in the same manner as quantitative responses. We coded open-ended responses using a codebook (Appendix B).

Assessing the Concerns of Key Social Groups

Some of our survey questions were designed to assess the concerns of recreationists, managers, and biologists regarding recreational use of the NCA. We summarized the concerns of recreational shooters, birdwatchers, managers, and biologists and used quotes to contextualize responses. Recreationists who participated in the on-site survey, managers, and biologists were asked an open-ended question about their concerns about recreation impacts at the NCA. Their responses were coded and summarized. We asked a subset of managers who frequently spent time at the NCA or routinely interacted with recreationists about specific areas of concern, which were conflicts between users, changes to recreation behavior, knowledge of rules, and adherence to rules.

Defining Standards of Quality

We used recreation type or occupation as social groups when defining standards of quality. We defined the standard of quality, or minimum acceptable impact, for

recreational shooters, birdwatchers, managers, and biologists at the NCA. We asked managers, biologists, birders, and recreational shooters to rate low, medium, and high trash conditions on a scale from very unacceptable (-2) to very acceptable (2), then plotted the mean acceptability rating for each condition of an indicator by social group (Needham and Rollins 2005). We used a Potential for Conflict Index (PCI) to show the amount of agreement within a group for each rating (Manfredo et al. 2003).

Comparing Standards of Quality

We compared standards of quality by group membership (shooters, birdwatchers, managers, biologists) and years of experience using an ordered logistic regression. We included a variable for survey format (interview, online) to check for differences based on how a respondent was surveyed. We created a regression model for each level (low, medium, high) of each indicator (trash, crowding) using the same set of variables.

Assessing Knowledge and Perceptions of Management Rules and Actions

To assess knowledge of management rules, we asked recreational shooters and birders an open-ended question about where they get information about management rules and regulations, then asked managers and biologists where they think recreationists get information and what would be the best sources of information.

To assess perceptions of management rules and action, we asked recreational shooters and birders to rate who is responsible for enforcing rules and regulations in a recreation setting on a scale from strong disagreement (-3) to strong agreement (3), then created a Potential for Conflict Index (PCI) to assess agreement within and between the groups. Lastly, we asked recreationists and management professionals about potential management actions that could be taken at the NCA. We gave recreationists a list of

general actions and instructed them to select all the actions they thought would be useful. We asked managers and biologists an open-ended question about what management actions would be helpful at the NCA.

Identifying Opportunities for Management Actions

We used the responses of recreationists, manager, and biologists to identify suggestions for management actions that address impacts of concern. We included an estimate of the level of resistance each action might be met with based on recreationists' perceptions of impacts, management agencies, and actions. We considered these opportunities and challenges along with the Rare Center for Behavior and the Environment's Levers of Behavior Change (Rare 2021) and theories of behavior change (Ajzen 1991, Kidd et al. 2019) to make suggestions.

Results

Survey Samples

We received 74 total responses to recreation surveys (54 recreational shooters, 20 birdwatchers). Of these, 62 recreationists (42 recreational shooters and 20 birdwatchers) and 20 natural resource professionals (10 managers and 10 biologists; Table 2.1) used the NCA at least once in the past year. No birdwatchers participated in the on-site survey. The majority of recreationists in our survey were male (86%), particularly within the on-site shooting sample (96%; Table 2.2). Recreationists were primarily from the Boise Metropolitan Area (79%) but varied in age, socioeconomic status, and educational background. Our sample of professionals was made up of 55% males and with 2 months to 44 years in their current position (Table 2.3). Management agency professionals included people focused on habitat, wildlife, and human uses (n = 8) and law

enforcement (n = 2). Some management professionals worked on the NCA specifically (IDARNG, BLM), while others manage wildlife (IDFG, USFWS) or resources (Idaho Power) in the region that includes the NCA. Biologists ranged in specialty, including habitat, illegal shooting, raptor ecology, wildlife management and conservation, movement ecology, long-billed curlew ecology, and ornithology.

Table 2.1. Sample size for each survey and interview format. We interviewed recreationists and professionals associated with the Morley Nelson Snake River Birds of Prey National Conservation Area in southwest Idaho.

Survey Format	Sample (n)	Response Rate (%)
On-site Interviews – Recreational Shooting	23	19*
Online Surveys	39	
Recreational Shooting	19	
Bird Watching	20	
Management Interviews**	10	29
Idaho Army National Guard	3	100
Idaho Fish & Game (Environmental)	1	33
Idaho Fish & Game (Law Enforcement)	2	40
Idaho Power	2	100
United States Fish & Wildlife Service	2	29
Research Interviews	10	67

* Response rate for on-site surveys is based on the number of vehicles that stopped at the survey location.

** The Bureau of Land Management professionals that we contacted for a survey were unable to participate because of agency restrictions.

Table 2.2. Demographics of survey respondents at the Morley Nelson Snake River Birds of Prey National Conservation Area in southwest Idaho summarized by survey format. Questions that were not asked in a particular survey are left blank. In cases where not all participants answered a question, we based summary statistics on the number of responses received.

Demographic	Overall *n = 62*	Shooting On-site *n = 23*	Shooting Online *n = 19*	Birders Online *n = 20*
Respondent Gender % (n)				
Male	76 (42)	96 (22)	100 (14)	33 (6)
Female	24 (13)	4 (1)	0 (0)	67 (12)
Age				
(mean ± SD)	48.2 ± 16.9	39.9 ± 17.0	52.9 ± 14.6	55.0 ± 14.5
Youngest	20	21	20	29
Oldest	73	70	72	73
Residence % (n)				
Boise Metropolitan Area	80 (49)	91 (20)	63 (12)	85 (17)
Other Idaho	7 (4)	9 (2)	5 (1)	5 (1)
Out of State	13 (8)	0 (0)	32 (6)	10 (2)
County (For Idaho Residents) % (n)				
Ada County	73 (38)	100 (21)	61 (8)	50 (9)
Canyon County	23 (12)	0 (0)	31 (4)	44 (8)
Jerome County	2 (1)	0 (0)	8 (1)	0 (0)
Twin Falls	2 (1)	0 (0)	0 (0)	6 (1)
Years at current residence (mean ± SD)	24.5 ± 17.8	21.5 ± 16.9	25.1 ± 19.3	27.9 ± 18.4
Number of People in Household (mean ± SD)	2.4 ± 1.1		2.6 ± 1.2	2.2 ± 1.0

Annual Household Income % (n)				
Less than $20k	0 (0)		0 (0)	0 (0)
$20 - 29k	3 (1)		8 (1)	0 (0)
$30 - 39k	10 (3)		8 (1)	11 (2)
$40 - 49k	16 (5)		23 (3)	11 (2)
$50 - 59k	13 (4)		0 (0)	22 (4)
$60 - 69k	10 (3)		0 (0)	16 (3)
$70 - 79k	6 (2)		8 (1)	6 (1)
$80 - 89k	10 (3)		15 (2)	6 (1)
$90 - 99k	3 (1)		0 (0)	6 (1)
$100 - 149k	13 (4)		15 (2)	11 (2)
Over $150k	16 (5)		23 (3)	11 (2)
Education Level % (n)				
Less than high school	2 (1)	0 (0)	7 (1)	0 (0)
High School Diploma/GED	13 (7)	19 (4)	14 (2)	6 (1)
Associate Degree	30 (16)	24 (5)	43 (6)	28 (5)
Bachelor’s Degree	28 (15)	33 (7)	29 (4)	22 (4)
Graduate Degree	27 (14)	24 (5)	7 (1)	44 (8)

Table 2.3. Survey sample of management and research professionals associated with the Morley Nelson Snake River Birds of Prey National Conservation Area in southwest Idaho.

Demographic	Overall	Management	Research
Respondent Gender % (n)			
Male	55 (11)	60 (6)	50 (5)
Female	45 (9)	40 (4)	50 (5)
Years in current position			
(mean ± SD)	12.3 ± 11.2	13.2 ± 7.6	11.3 ± 14.3
Minimum	0.2	0.2	0.6
Maximum	44.0	25.0	44.0

Concerns of Recreationists, Managers, and Biologists

The most cited concerns of recreational shooters were trash (59%), crowding (50%), safety (36%), and potential closures (27%; Figure 2.3). Because the question was only included in the on-site survey, birdwatchers are not represented in the response. Some shooters mentioned that they were not concerned about crowding because they were able to avoid people by [paraphrased] *Going further into the site, using the landscape to drop in and be safe, and practicing situational awareness*. Several shooters mentioned their concerns were affected by another shooting site on local public lands that had been closed for shooting because of littering and safety concerns (Blacks Creek Bird Reserve, Golden Eagle Audubon) [paraphrased] *I fear that if people aren't accountable, the BLM will shut down the area* [the NCA].

A few participants had specific concerns related to their background or past experiences. One shooter was particularly aware of birds of prey at the NCA and the impacts of lead [paraphrased] *Do people know this area is a birds of prey sanctuary? Lots of sportsmen hate lead-free shot because of the quality and some ballistics issues. And it's more expensive, which means less shooting. I'm not worried about lead in the ground, but I do worry that lead in ground squirrel carcasses will be eaten by a hawk and lead to lead poisoning. Most shooters wouldn't be worried about lead, but I'm a conservationist. There are so many birds of prey at the site, and I would hate to see birds disappear. It's a birds of prey sanctuary but also an area for shooting.*

Managers and biologists listed a greater variety of concerns than recreational shooters (Figure 2.3). The most cited concerns by managers were related to wildlife (70%), habitat degradation (50%), lead uptake by scavengers (50%), and safety (40%).

Biologists cited concerns for wildlife (90%), illegal killing of protected species (70%), habitat degradation (60%), safety (50%), lead (40%), and trash (40%). Wildlife concerns included general concerns for wildlife disturbance, displacement, and population impacts from recreation as well as specific concerns that were given their own category (illegal killing, lead). Habitat impacts included impacts from shooting, which one researcher described as [paraphrased] *Shrub sites that experience a lot of shooting can become bare ground when the shrubs get shot up.* Professionals were also concerned about habitat degradation from driving [paraphrased] *My biggest concern is driving. There are a lot of two-tracks* [from people driving off-road]*, which damage habitat and lead to vegetation and soil compaction, which then makes it easier for exotic annual species to establish in an area.* Fire was often mentioned along with habitat impacts or as a standalone issue for individuals concerned that driving over dry vegetation or using exploding targets could lead to fires (10% managers, 30% biologists).

Professionals expressed concerns for general safety and public safety at the NCA [paraphrased] *Even with formal Hunter Education you can't dictate common sense.* [There is] *Increased use coupled with increased population* [in and around the NCA]. *There are a lot of folks who don't think they're doing anything wrong. They don't think about how far bullets travel or the consequences of a stray bullet. People are blissfully unaware, not purposeful, in general.* There were also concerns for the safety of military personnel training and researchers collecting data at the site. One participant described their experience conducting research at the NCA [paraphrased] *It's nerve racking to be out there. Even when you tell shooters you're there, they don't adjust their behavior, so it's up to you to stay safe.* Another said [paraphrased] *The last couple years I've realized*

how far a bullet travels. When working in these areas, you have to be really aware of where people are shooting.

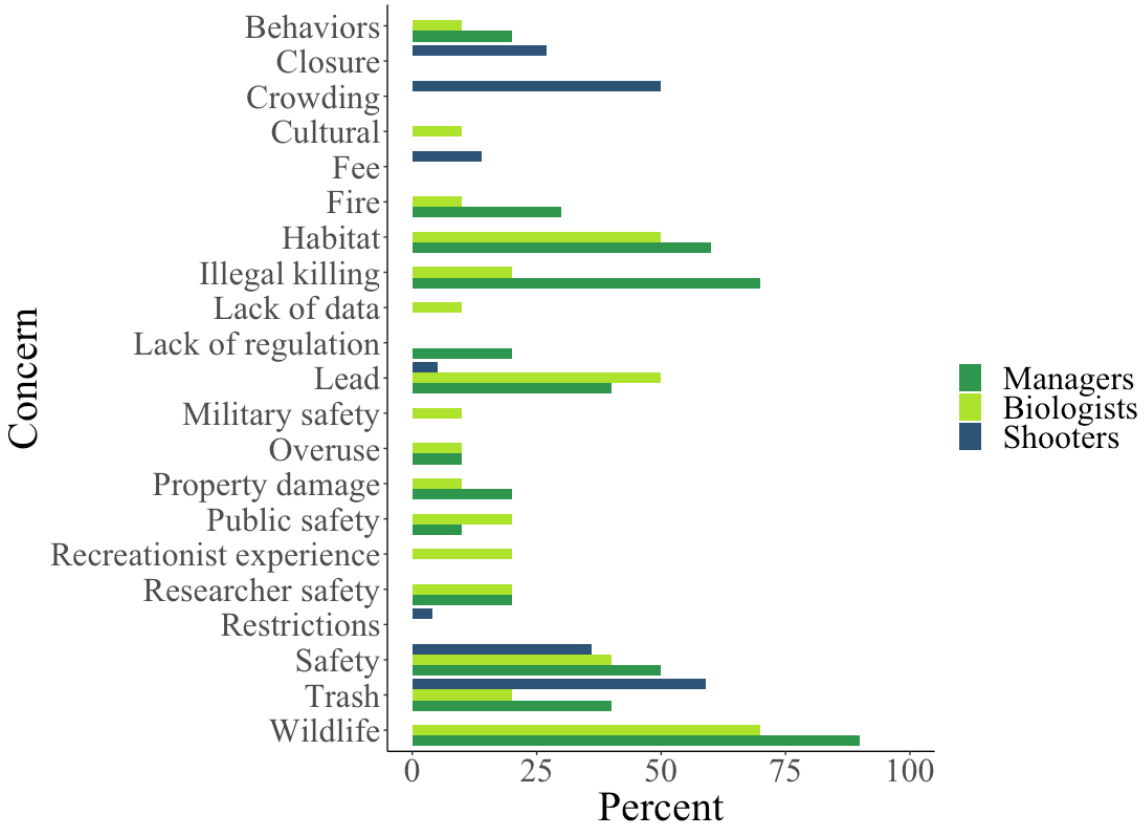

Figure 2.3. The percent of natural resource professionals and recreationists asked an open-ended question who mentioned each concern about recreation at the Morley Nelson Snake River Birds of Prey National Conservation Area in southwestern Idaho (*n* = 10 managers, 10 biologists, 22 shooters). Note that percentages total over 100% because some individuals mentioned more than one concern.

When we asked a subset of managers with more experience at the NCA (*n = 3*) about their concerns specific to conflicts between users, they most frequently cited crowding (50%), displacement (50%), and user safety (50%), while biologists (*n =3*) mentioned researcher safety (33%) or incompatibility with other user groups (33%; Figure 2.4). Displacement was thought to occur because recreationists avoid crowds or shooting specifically. One manager described this [paraphrased] *The area* [northern

portion of the NCA, along Pleasant Valley Road] *is mostly motorized and shooting use. Other users are deterred from the area. They self-separate because the area is unnerving. The area could have great mountain biking trails based on the topography, but it wouldn't be safe. You don't see many hikers in the area, bird watchers tend to avoid it. As long as I've worked here* [the NCA]*, the OCTC/northern NCA has been mainly guns and motorized groups and avoided by other user groups.* One biologist discussed the potential for indirect conflicts between birdwatchers and shooters, saying [paraphrased] *I could see how birdwatchers might not appreciate hunters, but I don't know of any physical confrontations.* Another biologist said they did not notice any conflicts at the site [paraphrased] *Everyone out there is kind of on the same page. Target and ground squirrel shooters and OHV users have a lot of overlap in participants. Other activities don't really overlap, either spatially or through the use of resources. All of the activities in this area* [the NCA] *have about the same level of destructiveness.*

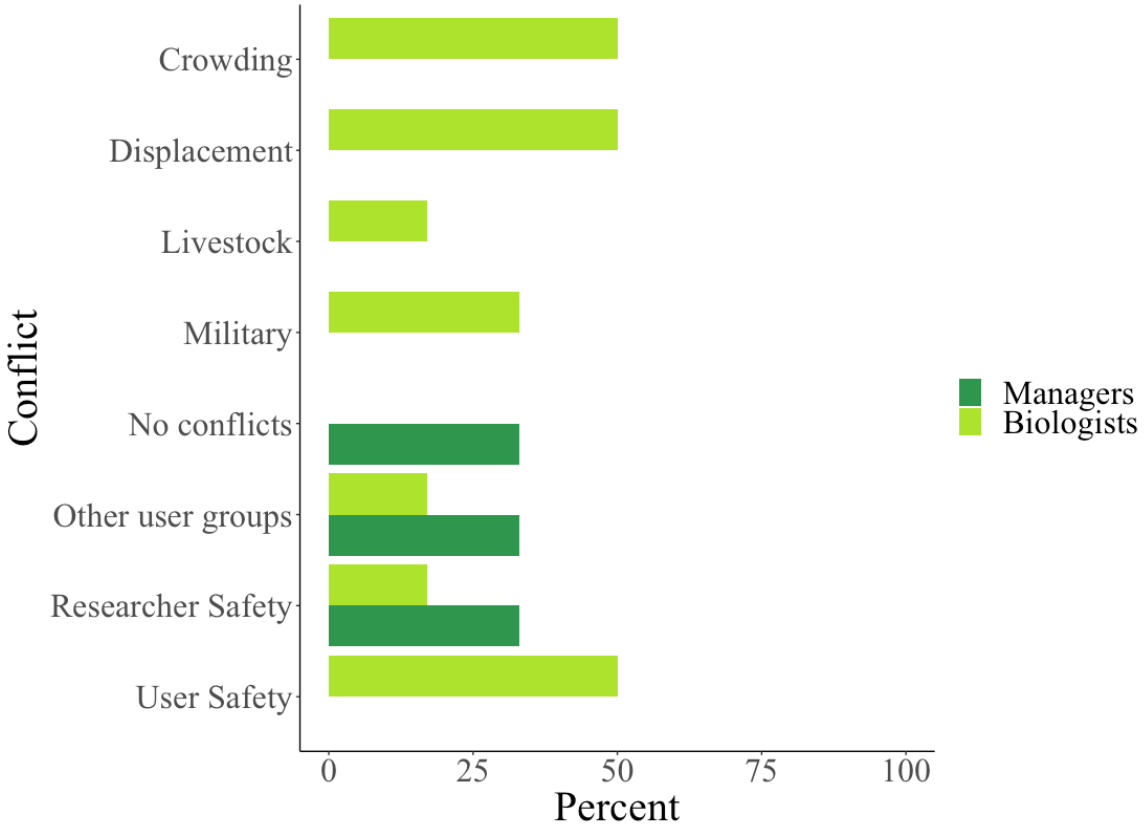

Figure 2.4. The percent of natural resource professionals (*n = 6*) who mentioned they were concerned about a particular conflict with recreation at the Morley Nelson Snake River Birds of Prey National Conservation Area in southwestern Idaho. Percentages may total over 100% because some individuals mentioned multiple concerns.

Managers described impacts to the behaviors of recreationists. A common theme was that bad behaviors lead to a wider acceptance and practice of that behavior. One manager described examples [paraphrased] *When shooting areas are clean, the next group doesn't leave garbage and will pick up their stuff. When there's trash at a site, generally the next group will leave more trash. If someone drives across open country on an ATV and people see it, they likely will also drive across open country. Seeing others behaving badly gives them the impression that, 'it's okay, nobody cares if I break this rule.'* Another manager noted that this phenomenon was particularly severe during the COVID-19 pandemic, calling it "mass hysteria" and recalling an increase in instances of

dangerous behaviors such as shooting out of moving vehicles. Several managers noted that law enforcement presence seemed to lead to better behavior. However, law enforcement professionals noted that [paraphrased] *It's hard to make an impact in an area like the NCA. Our* [law enforcement] *approach is to concentrate on a larger problem area. One issue is that people aren't out there for that long, then they leave and are replaced by new people. Because the site is so accessible and on public land, there is a constantly revolving population of users.*

When asked specifically if they were concerned that recreationists do not follow the rules, all managers and biologists responded that they were concerned. Professionals generally thought that shooters, or at least some portion of the group, know the rules and regulations and follow them (68%). However, a majority (53%) noted that there are also shooters who do not know the rules. A manager noted that this lack of knowledge may come from being new to the area or the sport. A smaller percentage of professionals (26%) thought that shooters know but do not care or worry about being caught. One management professional stated [paraphrased] *My suspicion is that a lot of the people who illegally shoot know the difference. They want to 'stick it to the man' or are shooting illegally for fun. For example, the kids who were caught shooting a golden eagle* (United States Attorney's Office 2022) *or people who go out at night.* Professionals also noted that there are cultural perceptions of species that are acceptable to kill (21%), even when that species is protected. For example, [paraphrased] *Killing rattlesnakes is seen as culturally acceptable in Idaho, and people often lump in other species of snakes with that.*

When asked about specific rules or species that there is a lack of knowledge of, birds (89% biologists, 60% managers) were the most common group of concern,

followed by specific subgroups of birds – raptors (89% biologists, 30% managers), long-billed curlews (67% biologists, 20% managers), and ravens (33% biologists, 30% managers; Figure 2.5). Snakes were also a common concern (44% biologists, 30% managers). Aside from species, managers (10%) and biologists (22%) also mentioned concerns that people do not know they need to attend Hunter Education or have a hunting license to shoot unprotected species. See Appendix B for recreational shooters' responses when asked to identify if groups of species are legal to shoot year-round in Idaho.

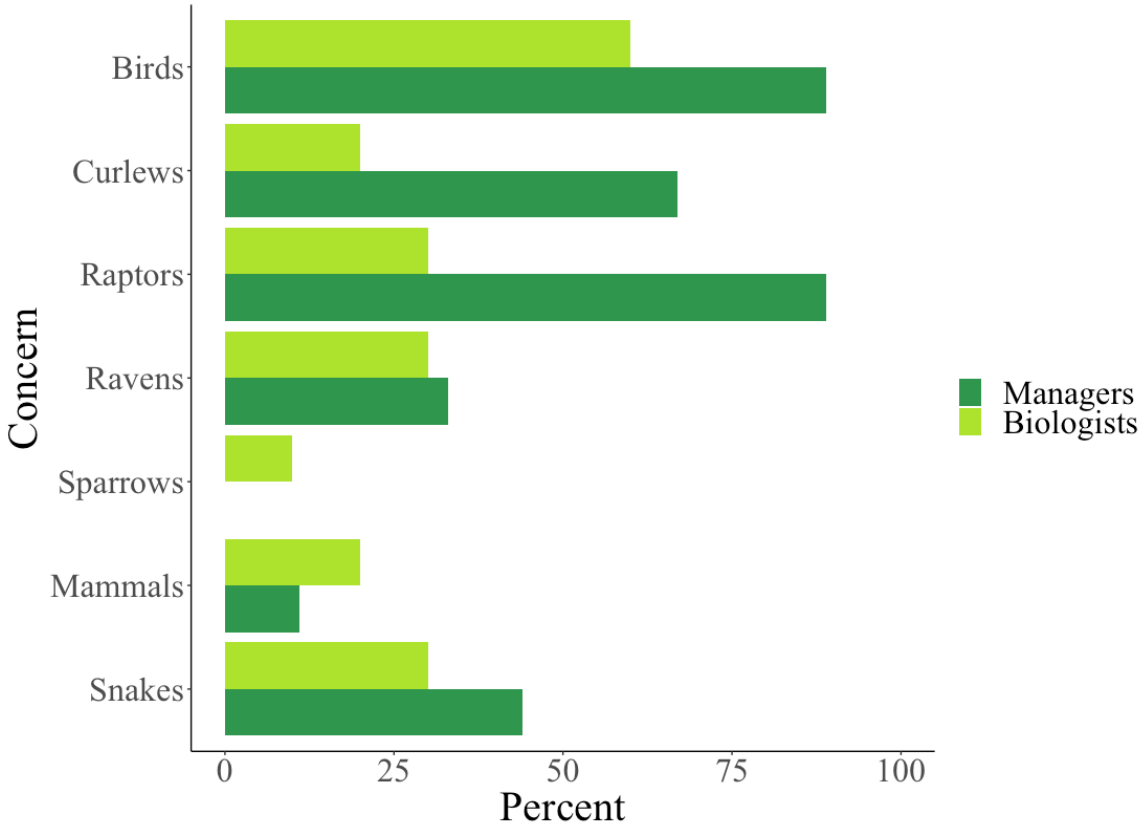

Figure 2.5. The percent of management professionals (*n* = 10 managers, *n* = 9 biologists) who mentioned a particular species/taxon of concern at the Morley Nelson Snake River Birds of Prey National Conservation Area in southwestern Idaho. Note that percentages may total over 100% because some participants mentioned multiple concerns.

Defining Standards of Quality

Trash

Biologists and managers rated all trash conditions with the lowest acceptability scores (Figure 2.6). Biologists and managers had low Potential for Conflict Indices (PCI), indicating high agreement within their groups. However, managers showed higher disagreement surrounding the low trash condition. Shooters and birders rated all trash conditions as more acceptable, and shooters gave the highest acceptability rating to each condition. Both types of recreationists had higher PCI, indicating more disagreement within the groups. The standard of quality, or minimum acceptable condition, was low trash for recreational shooters, birders, and managers. No level of the trash condition met an acceptable threshold for biologists.

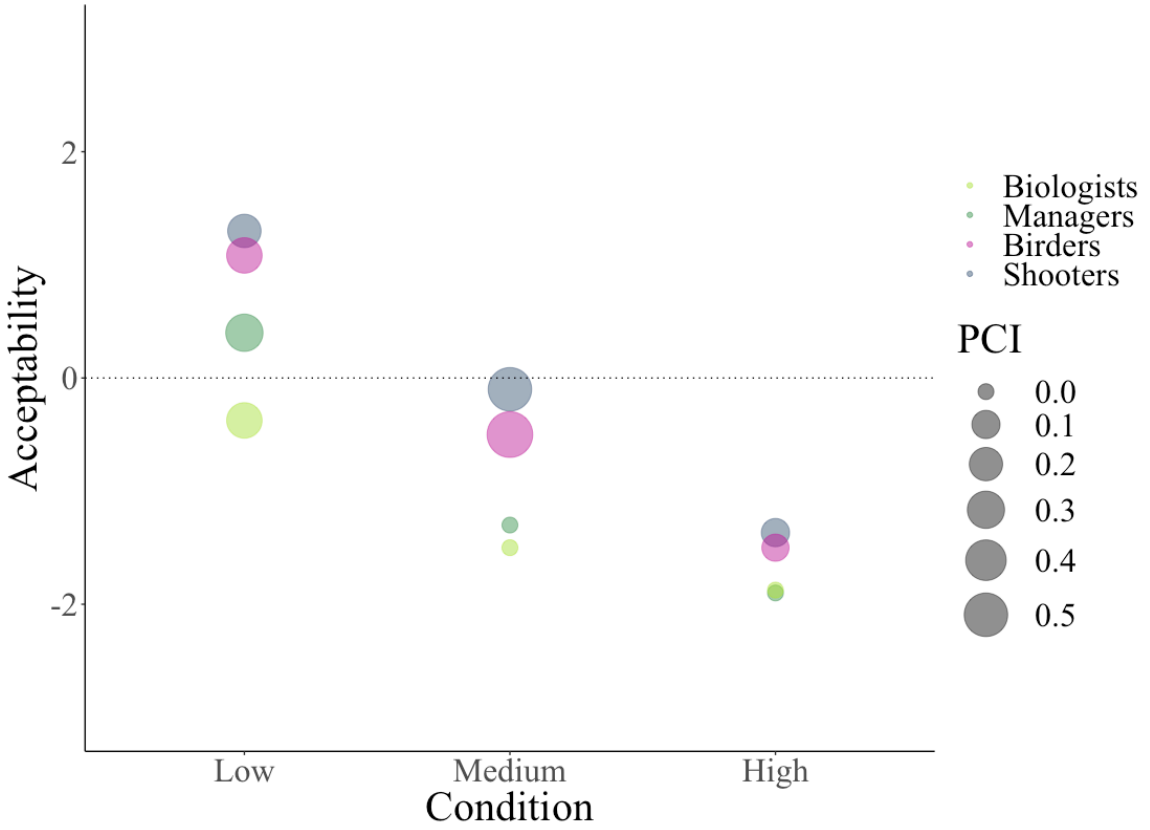

Figure 2.6. Acceptability of low, medium, and high trash conditions by birders (*n* = 12), recreational shooters (*n* = 30), biologists (*n* = 8), and managers (*n* = 10) at the Morley Nelson Snake River Birds of Prey National Conservation Area in southwest Idaho. Potential for Conflict Indices (PCI), indicated by the size of a bubble, are larger when there is more disagreement within a group.

Recreational shooters rated the low trash condition as highly acceptable. One participant mentioned that the low trash condition would make him want to pick up the site after shooting to keep it clean. Shooters generally rated the medium and high trash conditions as neutral or unacceptable and not something a "real sportsman" would leave behind, but many noted that they would still use the site. One recreational shooter stated, [paraphrased] [The medium trash condition is] *Ok for shooting. I go where the garbage is because it's nice to have a designated spot and not create more mess.* Another said, [paraphrased] *I view this* [high trash condition] *as unacceptable but useable. I would use a site that looks like this before shooting in a new, undisturbed area.*

One recreational shooting participant described his frustration with the trash and the negative reputation it gives shooting, [paraphrased] *You should pack out more trash than you pack in. Other people shouldn't have to pick up after sportsmen. Any real sportsman would take out more trash* […] *Most sportsmen are pretty conservation minded. It's not sportsmen dumping the trash, but they get blamed. It's a perception problem – people don't think sportsmen are conservation minded, and the trash doesn't help the cause.*

Managers and biologists rated the acceptability of the conditions from their professional perspective, so participants focused on different aspects of the condition. Several professionals mentioned that the low trash condition was still unacceptable because of habitat degradation and exotic annual species, which affected the availability of habitat for wildlife. Biologists who focus their research on species that use disturbed sites, such as long-billed curlews, rated medium and high trash conditions as more neutral than professionals focused on habitat. Some management professionals considered how current trash in a condition would affect future behaviors. One said, [paraphrased] *Any trash invites new trash, so this level* [the medium trash condition] *is unacceptable.*

Crowding

Recreational shooters rated all crowding conditions as unacceptable with little improvement between high and low levels (Figure 2.7). Shooters explained that the combination of crowding and the landscape would make the site unsafe for shooting at any level of crowding. Birders considered each condition acceptable and gave the highest rating for each level of crowding. The high crowding level was the standard of quality for birders. The standard of quality for managers and biologists was the medium crowding

condition, but both groups were concerned about safety and habitat impacts in the high crowding condition.

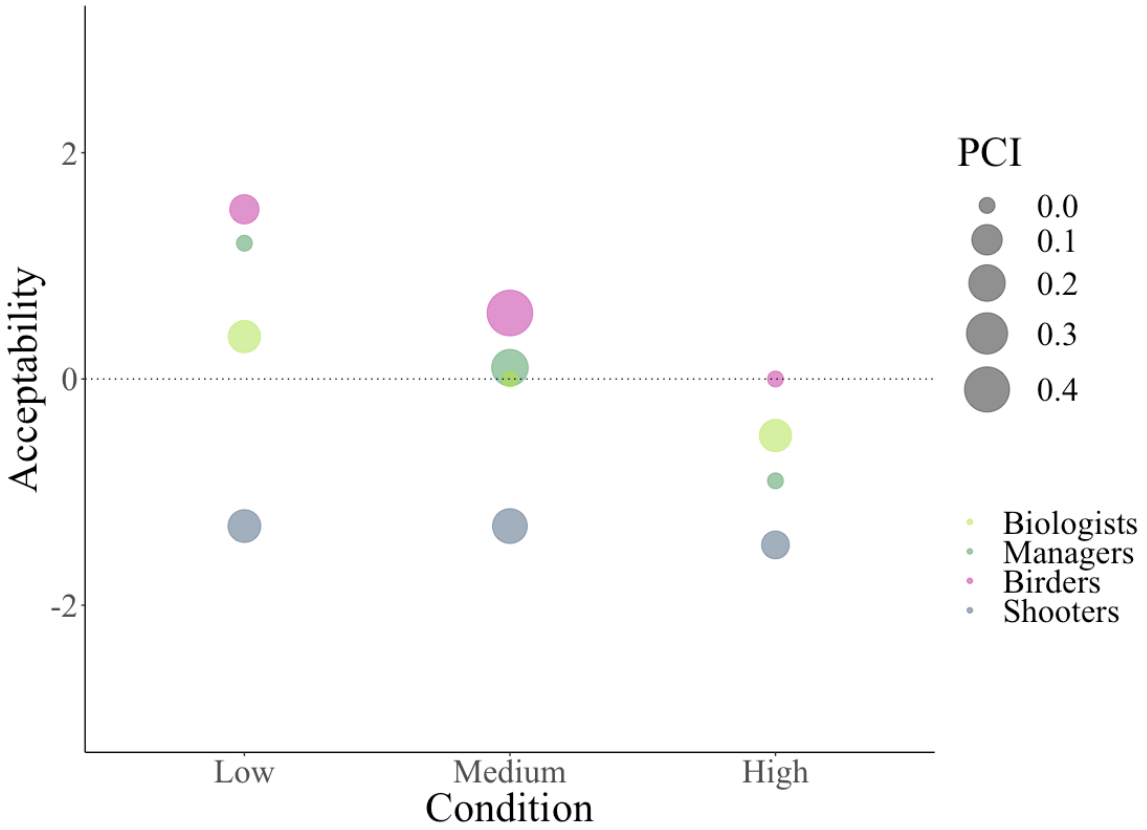

Figure 2.7. Acceptability of low, medium, and high crowding conditions by birders (*n* = 12), recreational shooters (*n* = 30), biologists (*n* = 8), and managers (*n* = 10) at the Morley Nelson Snake River Birds of Prey National Conservation Area in southwest Idaho. Potential for Conflict Indices (PCI), indicated by the size of a bubble, are larger when there is more disagreement within a group.

Comparison of Standards of Quality

In comparisons of acceptability ratings for each level of trash and crowding conditions, biologists and birdwatchers did not differ from the manager group, which was used as the reference group (intercept; Table 2.4). Recreational shooters rated low (β = 1.67 ± 1.07, P = 0.003) and medium (β = 2.14 ± 0.70, P = 0.002) trash conditions higher than the management group. Individuals with more years of experience recreating or in

their professional position rated low ($\beta = -0.04 \pm 0.02$, $P = 0.034$) and medium ($\beta = -0.04 \pm 0.02$, $P = 0.037$) trash conditions slightly lower than individuals with less experience. Survey format did not impact responses except for the low crowding condition where respondents who took the survey online rated the condition as more acceptable than those who participated in an in-person interview ($\beta = 2.21 \pm 0.93$, $P = 0.018$).

Table 2.4. Model parameters for ordered logistic regression models of acceptability ratings of trash and crowding conditions for managers, biologists, birders, and recreational shooters at the Morley Nelson Snake River Birds of Prey National Conservation Area in southwest Idaho. Group effects are relative to managers, which were the reference group.

Model Parameters	Odds Ratio	*β*	*SE*	*T*	95% CI	*P*
Low Trash Acceptability Model						
Biologists	0.49	−0.72	0.82	−0.88	−2.35 to 0.88	0.380
Birders	5.29	1.67	1.07	1.56	−0.42 to 3.78	0.118
Recreational Shooters	8.95	2.19	0.75	2.93	0.75 to 3.71	0.003
Years of experience	0.96	−0.04	0.02	−2.12	−0.08 to 0.00	0.034
Online Survey Format	0.63	−0.46	0.82	−0.56	−2.08 to 1.17	0.575
Medium Trash Acceptability Model						
Biologists	0.63	−0.47	0.84	−0.55	−1.21 to 2.85	0.580

Birders	2.23	0.80	1.03	0.78	−2.18 to 1.17	0.436
Recreational Shooters	8.47	2.14	0.70	3.06	0.80 to 3.56	0.002
Years of experience	0.96	−0.04	0.02	−2.09	−0.08 to 0.00	0.037
Online Survey Format	0.83	−0.18	0.75	−0.25	−1.68 to 2.28	0.806
High Trash Acceptability Model						
Biologists	1.09	0.08	1.49	0.05	−3.25 to 3.42	0.956
Birders	4.46	1.50	1.40	1.07	−1.04 to 4.80	0.285
Recreational Shooters	6.90	1.93	1.14	1.70	0.02 to 4.93	0.090
Years of experience	0.99	−0.02	0.02	−0.73	−0.06 to 0.02	0.466
Online Survey Format	1.11	0.10	0.83	0.13	−1.58 to 1.75	0.900
Low Crowd Acceptability Model						
Biologists	0.23	−1.45	0.87	−1.67	−3.22 to 0.23	0.095
Birders	0.38	−0.98	1.13	−0.86	−3.24 to 1.22	0.388

Recreational Shooters	0.01	−4.82	0.96	−5.03	−6.83 to −3.05	<0.001
Years of experience	0.97	−0.03	0.02	−1.20	−0.07 to 0.02	0.229
Online Survey Format	9.14	2.21	0.93	2.38	0.46 to 4.15	0.018
Medium Crowd Acceptability Model						
Biologists	0.93	−0.07	0.78	−0.09	−1.62 to 1.48	0.930
Birders	1.36	0.31	1.06	0.29	−1.77 to 2.41	0.771
Recreational Shooters	0.10	−2.34	0.73	−3.20	−3.84 to −0.95	0.001
Years of experience	0.99	−0.01	0.02	−0.58	−0.05 to 0.03	0.560
Online Survey Format	1.94	0.66	0.87	0.77	−1.04 to 2.40	0.443
High Crowd Acceptability Model						
Biologists	1.68	0.52	0.77	0.67	−1.00 to 2.05	0.930
Birders	3.67	1.30	1.11	1.17	−0.85 to 3.55	0.771
Recreational Shooters	0.26	−1.34	0.72	−1.87	−2.79 to 0.05	0.001

Years of experience	0.99	−0.01	0.02	−0.33	−0.05 to 0.03	0.560
Online Survey Format	0.77	−0.26	0.93	−0.28	−2.18 to 1.54	0.443

Knowledge and Perceptions of Management

Information About Management

When asked where they get information about recreating at the NCA, recreational shooters primarily reported that they get information from the Idaho Department of Fish and Game (83%), while birders get information from other management agencies (50%), online sources (33%), and the Idaho Department of Fish and Game (22%; Figure 2.8). Some participants listed multiple sources, so percentages total over 100%. Managers and biologists perceived that social groups are the most common source of information for recreationists (69%). Professionals reported the Idaho Department of Fish and Game (50%), other management agencies (36%), and Hunter Education (36%) would be the best places to get accurate information about rules and regulations. Sporting goods stores were mentioned as an avenue to spread accurate information to recreationists who might not know to check agency information.

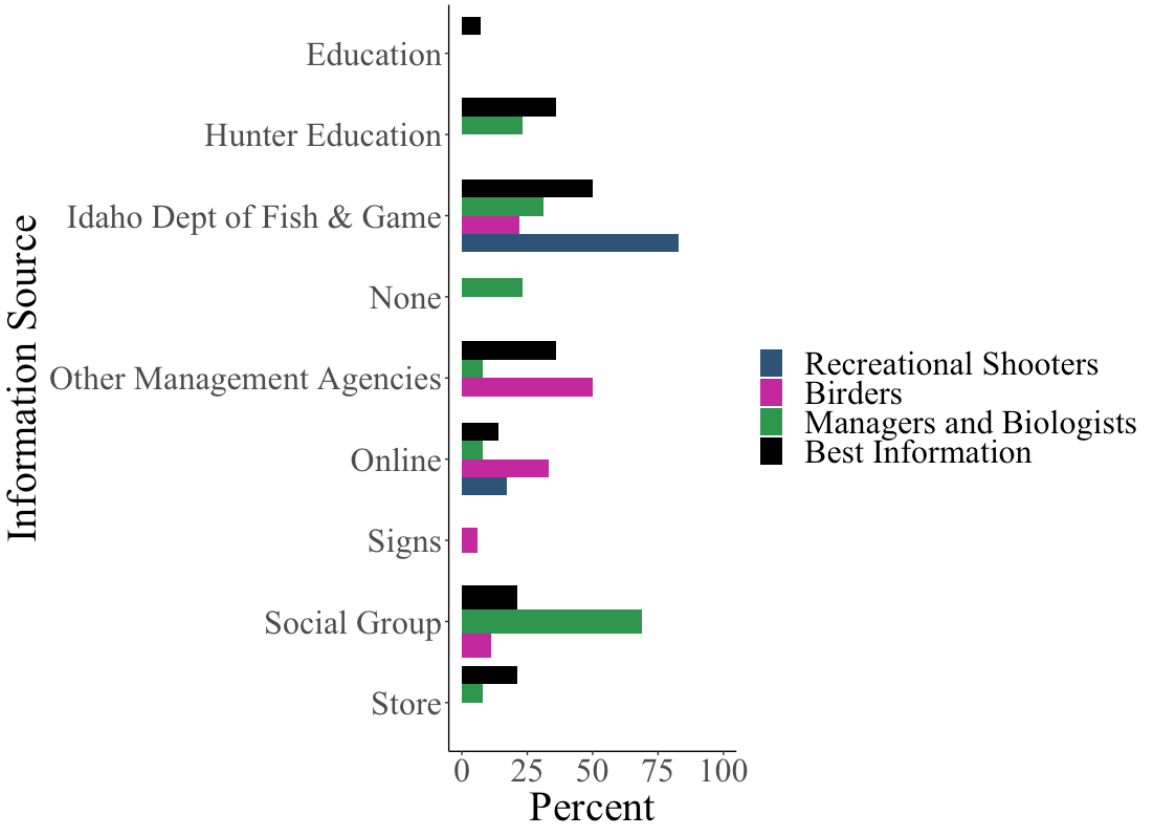

Figure 2.8. Sources of information about recreation rules and regulations reported by birdwatchers (*n = 18*) and recreational shooters (*n = 12*) at the Morley Nelson Snake River Birds of Prey National Conservation Area in southwest Idaho. Reported sources are compared to managers and researchers' (*n = 6*) perceptions of where recreationists get information and suggestions for the best places to get information. Percentages may total over 100% because individuals listed multiple sources of information.

Perceptions of Who Should Enforce Rules and Regulations

Recreational shooters and birdwatchers disagreed about the responsibility of various groups for enforcing rules and regulations in a recreation setting (Figure 2.9). Recreational shooters showed the highest agreement with the statement that individuals (Agreement = 2.79, PCI = 0.00) and law enforcement (Agreement = 2.18, PCI = 0.00) are responsible for enforcing rules and regulations. Birders showed the highest agreement with the statement that individuals (Agreement = 2.94, PCI = 0.00), law enforcement (Agreement = 2.44, PCI = 0.04), and management agencies (Agreement = 2.39, PCI =

0.04) are responsible for enforcing rules and regulations. The highest amount of disagreement between groups was seen in their perspectives of the responsibility of recreation groups (Agreement = 1.45, PCI = 0.30), other recreationists (Agreement = 1.41, PCI = 0.21), and management agencies (Agreement = 1.87, PCI = 0.16).

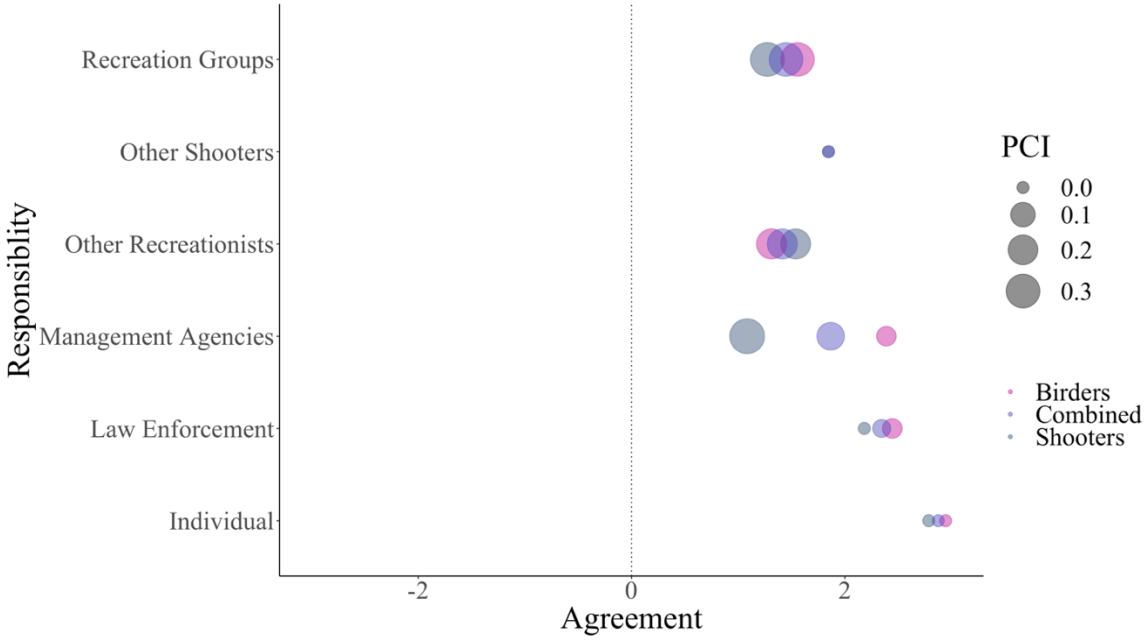

Figure 2.9. Recreational shooters (*n* = 19) and birders (*n* = 20) at the Morley Nelson Snake River Birds of Prey National Conservation Area in southwest Idaho agreement with statements about the responsibility of various entities to enforce recreation rules and regulations. Positive scores indicate agreement, negative scores indicate disagreement. Potential for Conflict Indices (PCI), shown with size, indicate the amount of disagreement within a group.

Perceptions of Management Actions

Of the listed options, recreational shooters were most supportive of public education (68%), while birders supported public education (45%), management changes (15%), and recreationist participation (15%; Figure 2.11). Only 5% of the birders and none of the shooters supported limiting use at the site. Several survey participants also mentioned specific ideas for management at the site, including putting a trash dumpster further north along the main access road, creating separate areas for OHV riders and

recreational shooters, fining people who leave trash, putting signs further north along the main access road, and creating an organized shooting area in the northern portion of the NCA. No participants in either group selected the option for "no change needed."

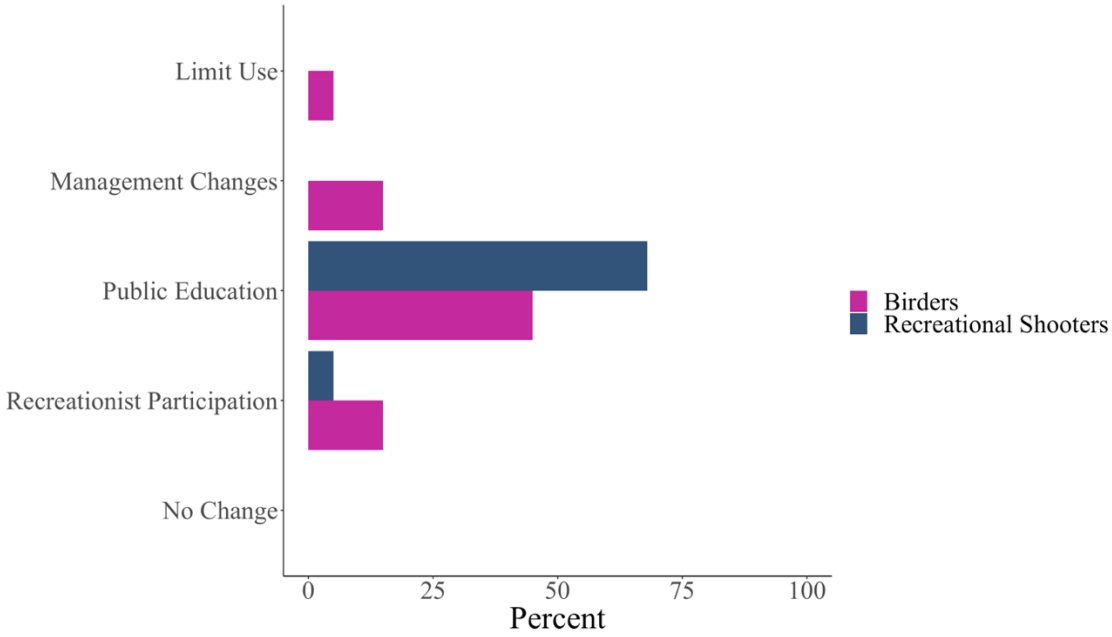

Figure 2.11. The percent of recreational shooters (*n = 19*) and birders (*n = 20*) at the Morley Nelson Snake River Birds of Prey National Conservation Area in southwest Idaho who agreed that a particular management strategy would help recreation at the site. Percentages may total over 100% because participants were able to select multiple strategies.

When asked an open-ended question about management actions, the most popular responses among managers and biologists were closures (57%), which included spatial or temporal closures to protect ecological resources or specific buffers around powerlines (14%; Figure 2.12). However, all professionals who mentioned closures said they viewed the option as a last resort and were worried about retaliation and effective enforcement with current resources. Other popular suggestions were increased law enforcement presence (43%), a designated shooting area (29%), and advertisement of consequences for breaking rules (29%).

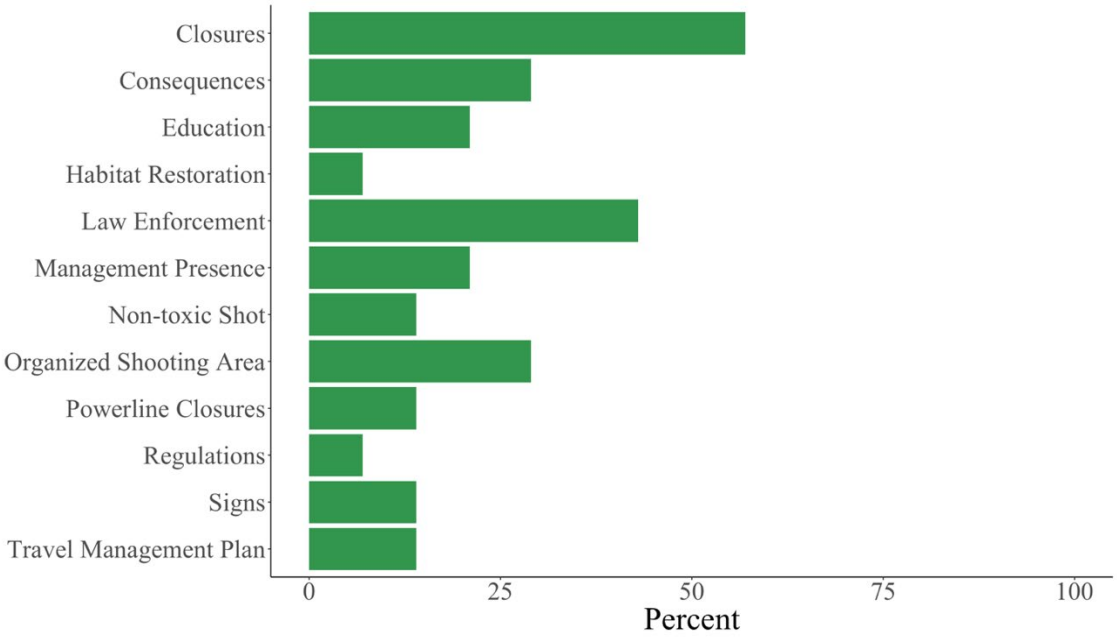

Figure 2.12. Percent of managers and biologists (*n = 20*) at the Morley Nelson Snake River Birds of Prey National Conservation Area in southwest Idaho who suggested a particular management action. Percentages may total over 100% because individuals sometimes mentioned more than one strategy.

Opportunities for Management

Recreationists and professionals offered suggestions for management actions that they believed would improve recreation at the NCA, some of which were consistent with social norms and behaviors described by survey participants (Table 2.5). The actions addressed three major concerns – trash, illegal killing of protected wildlife, and safety – and fell into various levers of behavior change (Rare 2021).

Table 2.5. Recreation impacts and proposed actions at the Morley Nelson Snake River Birds of Prey National Conservation Area in southwest Idaho, based off data gathered in this study.

Impact	Suggested Action	Rare 2021 category	Potential for resistance
Trash	Place more trash bins in high use locations at the NCA, including some located further north on the main access road	Choice architecture, material incentives	Low
	Use messaging to establish a social norm of picking up trash within the shooting recreation group	Social influences	Low
	Clean up trash at shooting sites, particularly in areas where shooting is discouraged (i.e., ecologically important areas)	Social influences, choice architecture	Medium
Illegal killing of protected wildlife	Provide basic information about shooting (e.g., where to find full regulations, hunting license are required to shoot unprotected mammals) at sporting goods stores	Information, social influences	Low
	Provide basic information about shooting at stops along access roads to the NCA on high use days	Information	Medium
	Increase law enforcement and management presence at the site	Material incentives	Medium
	Increase awareness of consequences of illegal killing of protected wildlife	Material incentives	Low
	Create a 1-km buffer around power lines and transmission lines where recreational shooting is restricted	Rules and regulations	High
Safety	Provide information about what makes an effective backstop (i.e., tall and wide enough to block all shots, appropriate distance from the shooting group, few to no rocks to prevent ricocheting bullets)	Information	Low
	Provide information about other users of the site	Information	Low

Discussion

Managers, biologists, birdwatchers, and recreational shooters at the Morley Nelson Snake River Birds of Prey National Conservation Area in southwest Idaho had differing perceptions of recreational impacts, challenges, and management. Recreational shooters were primarily concerned with trash and crowding at the site, while managers and biologists listed a variety of concerns that included wildlife disturbance, habitat degradation, illegal killing of protected wildlife, safety, and trash. Recreational shooters rated all trash conditions as more acceptable and all crowding conditions as less acceptable than managers, while birdwatchers aligned more closely with managers and biologists. Commonalities between the perceptions of natural resource professionals and recreation groups provide opportunities for managers to work with other groups to improve recreation at the NCA, whereas disagreements are areas where conflict may arise. When considered in the context of the Rare Center for Behavior and the Environment's Levers of Behavior Change (Rare 2021) and theories of behavior change (Ajzen 1991, Kidd et al. 2019), these provide a context for making suggestions to reduce conflict.

Opportunities for Providing Recreationists with Information

There have been criticisms of a knowledge-deficit approach to addressing conservation problems because of studies showing that knowledge does not necessarily lead to behavior change (Kidd et al. 2019). However, with the high portion of new users in the system and high support for educational strategies among recreationists at the NCA, there are opportunities for providing information to recreationists to encourage responsible recreation behaviors. First, managers were concerned that recreationists often

get information about the rules and regulations for the NCA from their social groups rather than better sources, such as the Idaho Department of Fish and Game, other management agencies, or Hunter Education courses. Recreationists may not realize that they need a hunting license if they plan to shoot unprotected mammals or not be aware of where to find information. Those who seek out information ahead of coming to the site may focus on where to recreate rather than the rules of the activity. Without accurate information about the site and expected behaviors, recreationists are expected to follow the behavioral norms they see from other recreationists at the site (Cialdini et al. 1990). This could perpetuate trash dumping, illegal killing of protected wildlife, and other undesirable behaviors by giving the perception that these behaviors are accepted by the recreation community. To combat this problem, several professionals suggested providing key information at sporting goods stores or other points where all recreationists would see them. This would provide clear information about basic rules and be delivered by members of the recreation community, which is likely to increase the receptiveness of recreationists to the information (Kidd et al. 1999, Rare 2021).

A second opportunity for education is the mismatch between concerns listed by recreational shooters, which focused on direct impacts to their activity, and the wide array of concerns listed by managers and biologists. Recreational shooters emphasized their concern for keeping the NCA open to the public, and individuals who were aware of specific issues, such as how lead fragments can impact health of wildlife and humans (Haig et al. 2014), showed concern for them. This, along with studies showing a higher awareness and concern for environmental issues among outdoor recreationists (Halpenny 2010, Cooper et al. 2015, Larson et al. 2018a,b), point to a benefit of educating

recreationists about environmental impacts (Rare 2021). In this system, there are opportunities to educate recreationists about fire risk, safety, other site users, and recreation impacts to wildlife, including species that may not be well-known or have confusion surrounding their regulations. Information is most effective coming from sources that are respected by the community, which could include recreation-based organizations, sporting goods stores, or Hunter Education classes (Kidd et al. 2019, Rare 2021).

Disapproval of Trash Within Social Groups

Managers, biologists, birdwatchers, and recreational shooters showed strong social norms regarding the high trash condition, which included large debris left at a site surrounded by shotgun shells, broken clay pigeons, and broken pieces. No level of impact was acceptable to biologists, who worried about habitat degradation and exotic vegetation even in the low trash condition. Managers and birdwatchers found the low condition acceptable, while recreational shooters found the medium and low conditions acceptable. Many recreational shooters in the survey reported that they remove trash after shooting at a site and were frustrated with their shooting activity being associated with trash dumping. The social norms of recreation groups, particularly shooters, could be used to make emotional appeals to recreationists to stop dumping trash at the site (Bernardo et al. 2014, Kidd et al. 2019). A message that emphasizes the social norm of leaving a site better than you found it or not dumping hazardous materials in the desert might be effective, especially if delivered by a respected organization or member of the shooting community (Cialdini et al. 2006). Appealing to the responsible sportsman mentality mentioned by several shooting participants could be effective for recreationists who

identify as sportsmen or women. This strategy may also be helpful for bringing in new users and setting expectations for their behavior at the site. Along with messages using social influence and emotional appeals, providing more dumpsters along main roads at the NCA would help to decrease the cost of picking up a site after shooting.

Mismatch Between the Injunctive and Descriptive Social Norms of Trash Dumping

Despite the strong injunctive social norm, or disapproval, of trash dumping among recreational shooters, there is a high instance of the behavior at the site. The descriptive social norm is visible to recreationists at the site, indicating that the trash dumping behavior is acceptable. This may counteract messaging about injunctive social norms and lead to increases in trash dumping (Cialdini et al. 1990, 2006). Management strategies that pair trash removal with social messaging would be more effective because the descriptive norm would match the injunctive norm used in the messaging. This phenomenon could affect messaging about social norms for other responsible recreation behaviors. The mismatch between reported injunctive norms and actual behaviors at the site could also point to additional social groups that were not represented in our survey efforts. This is likely because our sampling methods likely resulted in a sample of recreationists who are more experienced and dedicated users than the general recreation population.

Mismatch Between Low Tolerance for Crowding and Concern for Safety

Recreational shooters had a lower tolerance for crowding conditions than did birdwatchers, managers, and biologists. Recreational shooters attributed their low tolerance to safety concerns about the number of cars and people and the open landscape. This illustrates differences in social, landscape, and infrastructure needs for different

types of recreation. Crowding concerns, as well as needs for safe locations with a backstop to shoot into (Chapter 1), could be used to indirectly guide shooting use to specific, safe areas by providing improved backstops or creating designated "ranges" that are still have the feel of being in nature relative to a formal shooting range with facilities. These sites would provide safe, acceptable conditions for shooters while also concentrating shooting use away from other user groups.

Surprisingly, the low tolerance for crowding among recreational shooters was not matched by with a high concern for safety. This could be because shooters appear to use their location on the landscape to mitigate safety concerns. They describe finding sites that are lower than the surrounding hills or far enough away from other groups to be safe. Shooters also place a high responsibility on the individual to follow rules and regulations and to stay safe. This, combined with the perception among recreational shooters that shooting and OHV users are the only other groups at the NCA, likely contributes to the safety concerns that managers and biologists have for individuals conducting research or participating in military training at the NCA.

Constraints of the Limits of Acceptable Change Approach

In our assessments of limits of acceptable change, we used levels of social and environmental conditions that were representative of conditions experienced by recreationists at the study site. Because of this, our photos differed from what has been previously used in studies of limits of acceptable impacts in recreation systems (Manning and Freimund 2004, Manning 2011). As a result, our indicators may fall short of meeting Manning's (2011) criteria, which state that they should be specific, objective, measurable, and repeatable. Notably, crowding is typically shown with an increasing

number of people on a trail or at an attraction. Instead, we used the number of vehicles and groups across the landscape. One potential effect of this is that survey participants evaluated other landscape characteristics, such as roads, powerlines, topography, and backstops, along with the amount of crowding. Some participants considered landscape features and crowding levels in their acceptability score. This was a tradeoff for using conditions that were representative of the site, but future work could improve the assessment of crowding at a landscape scale. This could be done by making measurements quantitative, rather than high, medium, and low categories (Manning 2011). In assessments of crowding, measurements could be improved by controlling for the number of useable sites in the larger landscape shown to participants.

Addressing the Illegal Killing of Protected Wildlife Species

Illegal killing of protected species was a concern for managers and biologists and was documented at the study site in a recent publication (Katzner et al. 2020). Managers and biologists were especially concerned about recreationists' (lack of) knowledge regarding regulations for shooting raptors, long-billed curlews, ravens, and snakes. Long-billed curlews were mentioned as a species that many people are unaware of and one that may resemble a game bird. We expected confusion about the rules for killing ravens because there is a season for shooting crows, but ravens are illegal to kill (Idaho Department of Fish and Game 2022). Snakes were thought to be at risk because of cultural perceptions that killing snakes is acceptable, even helpful, or necessary. It was generally assumed that people know raptors are illegal to shoot, which is consistent with our preliminary survey findings (Supplemental Materials 1). However, raptors may be persecuted because of cultural beliefs or targeted because their affinity for perching on

powerlines makes them a tempting target. Educational efforts that focus on these species may be particularly useful if aimed at the portion of illegal shooting that happens incidentally (Rare 2021). However, this is only effective for people who can be affected by new information. For a subset of people who engage in illegal killing, increasing law enforcement and awareness of consequences may be more effective in changing behavior (Saypanya et al. 2013).

Distrust for Management Among Recreational Shooters

An area of potential conflict arose in discussions of potential management actions. Recreationists agree that change is needed but disagree about what should be done and the responsibility of management agencies. Recreational groups both placed the highest responsibility on individuals and law enforcement for enforcing or following rules at the NCA. However, they disagreed about the responsibility of management agencies, with recreational shooters placing less responsibility on agencies. This could lead to resistance from recreational shooters when management agencies try to act (Muboko et al. 2016). Further, when asked about potential management actions, managers and biologists frequently suggested closures, increased law enforcement, and a designated shooting area. Though temporal or spatial closures might be warranted for wildlife conservation reasons, limits to use were not supported by recreationists, and closures are a specific concern listed by recreational shooters. Managers typically noted the potential for retaliation or conflict from closures and emphasized the strategy was a last resort or limited to a specific area, such as a buffer around power lines or transmission lines where birds are frequently shot illegally (Katzner et al. 2020). In a large area with few resources or enforcement personnel, indirect management strategies or actions with support from

recreationists have the highest chance for success. Asking recreationists to rate the acceptability of management strategies in response to specific scenarios (e.g., Thomsen et al. 2022) could provide a more specific understand of the recreationists' support for management actions.

Conclusion

Together, our findings suggest areas with opportunities for improving recreation at the site and areas with the potential for conflict. Recreational shooters stand out as a recreation group with more specific concerns and perceptions of acceptable impacts than birdwatchers, who are more closely aligned with managers and biologists. The social group of recreational shooters presents an opportunity to use social norms and strategies for behavior change to reduce conflicts and make the activity more compatible with the multiple-use public land where it occurs. Decreasing conflicts will help to promote the enjoyment of public lands and provision of recreation opportunities.

CHAPTER THREE: IMPACTS OF OUTDOOR RECREATION ON MULTIPLE LEVELS OF A FRAGMENTED SAGEBRUSH-STEPPE ECOSYSTEM

Abstract

Outdoor recreational use is growing rapidly in the western United States, which increases the pressure on multiple-use public lands. Balancing recreational use with conservation goals requires considering the spatial and temporal intensity of recreational use and examining its effects relative to other factors on these landscapes. We assessed the relationship between recreational intensity and the abundance of a dominant prey species (Piute ground squirrels, *Urocitellus mollis*), the abundance of avian and mammalian scavengers that rely on ground squirrels, and the breeding density and nesting success of ground-nesting birds at a National Conservation Area in southwestern Idaho where recreational shooting and off-highway vehicle use are the primary recreational activities. The abundance of ground squirrels had a positive relationship with recreational intensity but was more strongly related to the presence of native shrub cover. The abundance of avian scavengers, particularly common ravens (*Corvus corax*), was positively associated with recreational intensity, as well as powerlines and development. The density of a common mammalian scavenger, American badgers (*Taxidea taxus*) was positively associated with recreational intensity. Breeding bird density and nesting success of ground-nesting birds were negatively related to recreational intensity, with the nest success of a more sensitive species, long-billed curlews (*Numenius americanus*), being most strongly related. Together, our results highlight the importance of considering

variation in recreation intensity, the effect of recreation relative to other conservation threats, and the impact of recreation on multiple levels of the ecosystem.

Introduction

Multiple-use public lands include important habitat for conservation and provide opportunities for human use, including outdoor recreation. On public lands where recreational use is growing, managers are tasked with the increasingly difficult duty of balancing human use and enjoyment of the landscape with the conservation of wildlife and plant populations that rely on the same areas. This is an urgent concern in the western United States where the human population and outdoor recreation on public lands have increased rapidly since the 1990s (Hansen et al. 2002, Leu et al. 2008, Lybecker 2020). As human use of western US landscapes continues to expand and change, the dynamics of recreationists and public lands are an increasingly important consideration.

Providing recreation opportunities and promoting conservation are two common goals of the US agencies that manage public lands (Interagency Visitor Use Management Council 2019). However, these goals can be in opposition, as outdoor recreation impacts multiple levels of an ecosystem. Impacts of recreation may be direct, through disturbance or harvest, or indirect, through habitat modifications or altered relationships between species (Larson et al. 2016, Sumanapala and Wolf 2019). Wildlife species are thought to react to humans as if they were potential predators (Duffus and Dearden 1990), and the response of a species to recreation depends on its ecology and history with humans (Larson et al. 2016, Tablado and Jenni 2017, Dobbins et al. 2020, Smith et al. 2021). Some species may be able to continue to use habitats with high levels of recreational use, and others may even benefit from the presence of recreational users or infrastructure

(Miller et al. 1998, Boarman 2003, Bui et al. 2010). Differing effects among species in an ecological community can lead to changes in species composition or interspecific interactions (Dobbins et al. 2020). Considering multiple levels of the ecosystem gives us a more complete understanding of how recreational use on public lands impacts conservation goals.

The intensity of recreational use may impact the degree of its effects on wildlife. In studies of recreational ecology, recreational use is typically treated as a static impact (Sumanapala and Wolf 2019). This ignores variation in use over space and time within a recreation area (Riungu et al. 2018, Peterson et al. 2020) and the effects of environmental conditions on recreation, both of which are needed for a more comprehensive approach (Miller et al. 2021). Studies that account for the intensity of recreational use when examining its impacts have primarily focused on biophysical impacts, such as trampling of vegetation, and have found more severe impacts with higher use (Cole 1986, 2019, Whinam and Chilcott 2003, Sumanapala and Wolf 2019, Dobbins et al. 2020). Accounting for the dynamic nature of recreational use helps us to better understand how recreation is related to wildlife and conservation outcomes.

In the sagebrush-steppe ecosystem, it is also important to consider how recreation is related to vulnerable wildlife species relative to vegetation and landscape features. Many species rely on native sagebrush and forb communities for food, cover, or nesting sites (Knick et al. 2003, Steenhof et al. 2006, Parker 2021). Wildfires, invasive species, livestock grazing, agricultural conversion, natural resource extraction, and urban development are common disturbances in this environment that lead to changes in the vegetation composition and structure or alter ecosystem processes (Knick et al. 2003).

Understanding the impacts of recreation in the context of varied vegetation composition, development, roads, and power lines provides more specific information about drivers of observed ecological outcomes.

We examined how outdoor recreation, primarily recreational shooting and off-highway vehicle (OHV) use, impacts multiple trophic levels of a fragmented sagebrush-steppe ecosystem in southwestern Idaho. We quantified recreation for specific locations and periods of time to consider impacts on a finer scale. Our study included the key vertebrate species in the food chain: the most abundant mammalian prey species, avian and mammalian predators and scavengers, and ground-nesting birds. In this system, trails, roads, and recreation-caused wildfires fragment wildlife habitat and provide easy paths for predators, which may lead to lower densities of breeding birds and increased nest predation (Miller et al. 1998, Fernandez-Juricic 2000). Foot traffic or OHV use by recreationists may disturb breeding birds, reducing the time and energy an individual can spend on behaviors that increase reproductive success (Duffus and Dearden 1990). Recreational shooting, which includes shooting inanimate targets and live animals, may impact the ecosystem directly through disturbance or legal and illegal killing of species (Katzner et al. 2020) and indirectly through scavenger supplementation. Scavenger supplementation occurs when carcasses left after a shooting event attract and support increased numbers of aerial and terrestrial scavengers (Lafferty et al. 2016, Mctee et al. 2019, Herring et al. 2021). This could lead to increased predation on ground-nesting birds (Boarman 2003, Bui et al. 2010). Higher scavenger abundance may be observed permanently or during the period of increased resource availability in areas where supplementation occurs (Holt 2008). Scavenger supplementation is well-documented in

cases where big game hunters leave portions of their kill, such as a gut pile, in the environment (Mateo-Tomas et al. 2015, Lafferty et al. 2016, Gomo et al. 2017), but its effects are less well-understood for smaller, less persistent carcasses – such as those provided by ground-squirrels, prairie-dogs, and other smaller mammals that are frequently shot for sport – that are on the landscape during the breeding season (Mctee et al. 2019, Herring et al. 2021).

We tested the hypothesis that recreational intensity is related to the abundance of a dominant prey species often targeted for shooting, the abundance of avian and mammalian predators that rely on the dominant prey species, and the breeding density and nesting success of ground-nesting birds that may be affected by changes in the abundance of the dominant prey species and its predators. Specifically, we predicted that as recreational use increases, (1) the abundance of dominant prey species decreases, (2) the abundances of avian and mammalian predators increase, and (3) the breeding density and nesting success of non-target bird species decrease (Figure 3.1). We compared the relationship of recreational intensity and each variable of interest relative to the relationships of vegetation and landscape features known to be important.

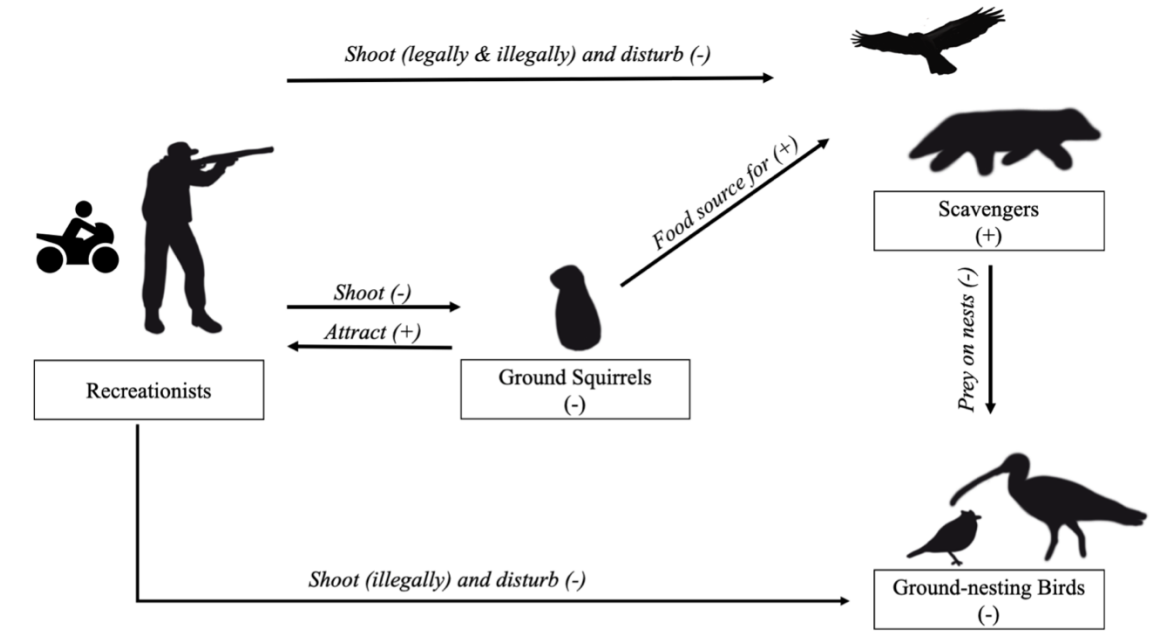

Figure 3.1. Hypothesized interactions between outdoor recreation and multiple levels of a sagebrush-steppe ecosystem. Plus (+) and minus (-) signs indicate a predicted positive or negative impact in the arrow direction. For example, we expect that recreationists focused on target shooting would be attracted to areas with high numbers of ground squirrels and that their shooting activity will decrease ground squirrel numbers, at least in the short term.

Study Area

We conducted our study at the Morley Nelson Snake River Birds of Prey National Conservation Area (hereafter, NCA; Figure 3.2), located approximately 30 km south of Boise, Idaho, USA. The NCA was established in 1993 because it supported the largest, densest known population of nesting raptors in North America (Public Law 103-64). The NCA includes a river canyon with abundant cliff-side nesting sites for raptors and extensive shrub-steppe and grassland areas that provide habitat for a variety of mammalian and avian prey species. The NCA was historically covered in shrubland, primarily big sagebrush (*Artemisia tridentata*), as well as native grasses and forbs. Wildfires, livestock grazing, habitat fragmentation, and drought have degraded the site, and much of the native vegetation has been converted to cheatgrass (*Bromus tectorum*)

and other exotic annual grasses and forbs (Kochert et al. 1986, Pilliod et al. 2017, Parker 2021). Despite this habitat degradation of the upland desert areas, the NCA still supports sizeable populations of many native wildlife species.

The US Bureau of Land Management (BLM) manages the NCA. The Orchard Combat Training Center (OCTC), a Department of Defense training center located on BLM land within the NCA is jointly managed by the BLM and the Idaho Army National Guard (IDARNG). Agriculture, livestock grazing, energy transmission, research, management activities, military training, and outdoor recreation take place within the NCA. Outdoor recreation includes OHV use, recreational shooting, birdwatching, hiking, camping, boating, fishing, and climbing. The number of recreationists varies across the site due to accessibility, based on the presence of roads and distance from major cities (Pauli et al. 2019). This creates a unique outdoor laboratory with a mosaic of recreational use intensities that span multiple vegetation types, which was ideal for testing the relationships of recreational use and multiple levels of the sagebrush-steppe ecosystem.

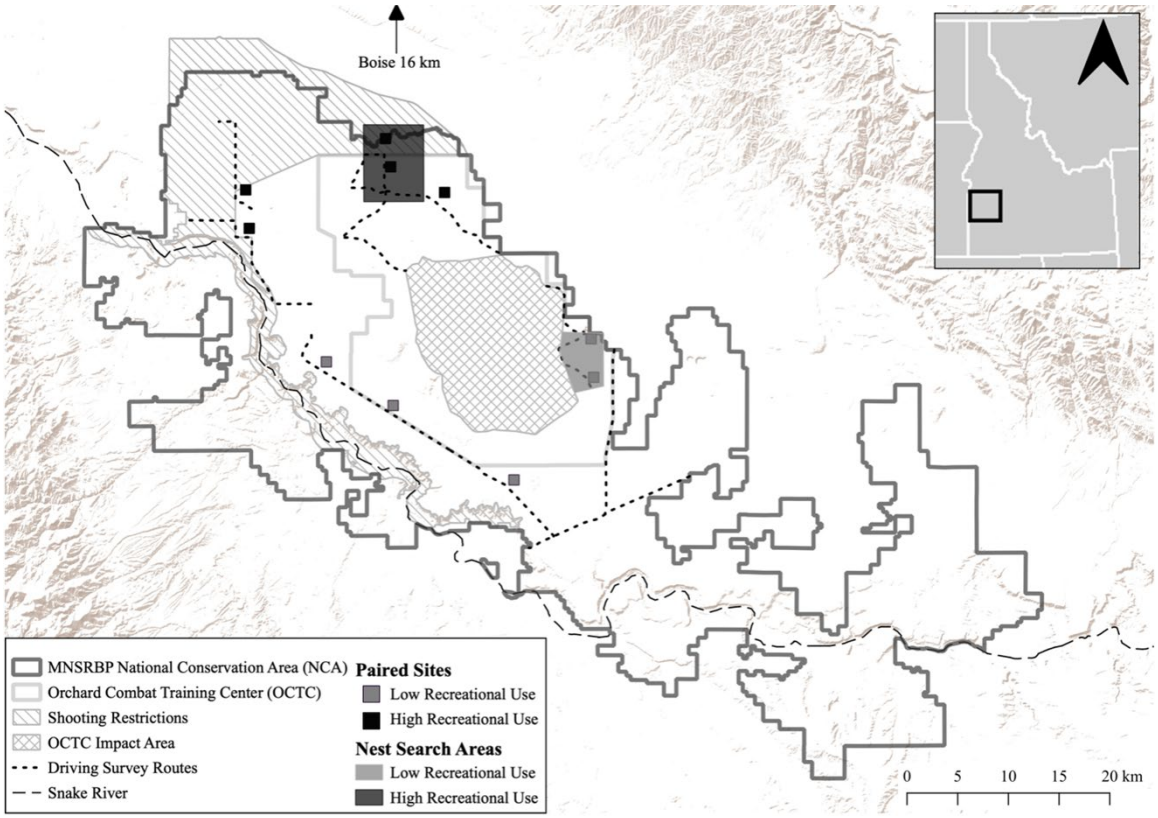

Figure 3.2. Map of the Morley Nelson Snake River Birds of Prey National Conservation Area (NCA) in southwest Idaho. Paired 1-km2 sites, nest search areas, and driving survey routes are shown. The NCA is open to recreation except for the Orchard Combat Training Center Impact Area, which is not accessible to the public, and several areas with shooting restrictions.

Methods

Within the NCA, we surveyed for wildlife in 10 1-km^2 paired sites in locations with relatively high (n = 5) and low (n = 5) recreational use. We paired each 1-km^2 site with a site of opposite recreation intensity and similar vegetative composition, based on percent shrub cover and combined grass and forb cover. We compared land cover between the 1-km^2 paired sites to reduce the likelihood that one group of sites was not biased by a variable other than recreation (Appendix C). We also designated two larger areas for more intensive monitoring of ground-nesting birds, one in each level of recreational use. Each of these larger areas included 2 of the 1-km^2 sites.

We considered the impact of recreation intensity on the abundance of Piute ground squirrels (*Urocitellus mollis*); raptors, common ravens (*Corvus corax*), and American badgers (*Taxidea taxus*); and the breeding density and nest success of ground-nesting birds. Piute ground squirrels are a dominant species, an important prey species for many predators at the site, and a common live target for recreational shooters (Steenhof et al. 2006). To assess scavenger impacts, we included species that have the potential to eat the ground squirrel carcasses left after a shooting event while also being effective nest predators. Scavengers include ravens, badgers, and the full community of raptors at the site. We included the two most numerous ground-nesting bird species in the study area, horned larks (*Eremophila alpestris*) and long-billed curlews (*Numenius americanus*), which have the potential to be affected indirectly by changes to the dominant species and predators. Examining the impact of recreation on the nesting success of both species enabled us to compare species that utilize similar environments and have similar nest predators but may differ in tolerance to disturbance. Long-billed curlews are shot illegally at this site (Katzner et al. 2020), are a species of conservation concern, and are in decline locally (Idaho Department of Fish and Game 2017). As a common species that is not listed as a species of conservation concern, horned larks provided an opportunity to compare the effects of recreational use on nesting success with a smaller species that experiences similar levels of recreational disturbance but is less likely to be illegally shot.

We collected information about recreational use, ground squirrel abundance, raptor and raven abundance, badger abundance, and ground-nesting bird breeding density at each of the 1-km2 sites. Within the larger nest search areas, we found and monitored horned lark and long-billed curlew nests to assess nest success. In 2021, all elements of

the study were underway simultaneously. We collected additional data in prior years for curlew nesting success (2019−2020), horned lark nesting success (2020), and recreational use (2019−2020).

Field Methods

Recreational Use

We assessed recreational use by expanding on a procedure established by Pauli et al. (2019) who used 3 survey routes to characterize and model recreation habitat suitability. We surveyed 10 16-km driving routes spread across the upland habitats of the NCA that passed through a variety of land cover types and used publicly accessible major and minor roads (Figure 3.2). From April 2019 to July 2021, we drove the routes each Saturday during the peak recreational shooting season (March − July) and on one randomly selected Saturday per month throughout the rest of the year. During the routes, we recorded the location of each observation of recreational use. We classified recreational use as motorized recreation (off-highway vehicles, driving off-road), target shooting (shooting at targets or other inanimate objects, stationary), hunting (moving through vegetation and shooting, no inanimate targets), non-motorized recreation (hiking, birdwatching, biking), or other (camping, photography). All types of recreational use were combined in our calculations of recreation intensity, described in the analysis section.

Ground Squirrel Abundance

We conducted three surveys at each 1-km2 site between 6 May and 14 June 2021 to estimate ground squirrel abundance (J. Cruz, Boise State University, personal communication). At each site, we selected a 100 m x 100 m area where we counted Piute

ground squirrels. We placed survey areas in the corner of each site closest to the road (but at least 50 m from the road) and in areas with vegetation that represented the larger 1-km2 site (Appendix C). We counted each independent auditory or visual detection of ground squirrels along 100 m transects along the border of survey area and for two minutes at each corner. Because Piute ground squirrels emerge at different times post sunrise depending on weather conditions (Steenhof et al. 2006), on each survey day we waited to conduct surveys until squirrels were observed above ground to maximize our chance of detecting squirrels where they were present.

Raptor and Raven Abundance

Within each site, we conducted systematic walking surveys along a 4x4 grid of 16 points spaced by 250 m (Appendix C). The same observer conducted 8 surveys per site from 6 May to 17 July 2021. Duration and distance varied across surveys (90 − 120 min and 4.0 − 4.3 km, respectively) due to differences in topography and time spent recording observations. We surveyed each site at a range of times to avoid confounding site with the time of day the survey was conducted. At the start of each survey, we recorded the date, time, wind speed (km/hr), and temperature (°C). During the walking surveys, we recorded independent auditory and visual detections of raptors and ravens, the number of individuals detected, the species or most specific identification possible, and the location of the bird (in the grid, within a 250 m buffer surrounding the grid, or more than 250 m outside of the grid).

Badger Abundance

At each 1-km^2 site, we deployed two motion-sensing cameras from 4 April to 16 July 2021. We placed the cameras approximately 250 m to the north and south of the

center point of each site (Appendix C). Once we reached the approximate location, we chose a camera site and direction that would maximize the probability of detecting badgers. We applied a scent bait (Heck's L.D.C. Predator Bait) at each camera to attract badgers to the camera location. We visited each camera weekly to download SD cards and change batteries, and we reapplied bait every two weeks.

Ground-nesting Bird Breeding Density

We conducted a point count survey for horned larks and long-billed curlews at each 1-km2 site between 2 - 14 April 2021, a time when both species sing and display frequently. We created used the grid of 16 survey points spaced by 250 m (Appendix C) and followed the Integrated Monitoring in Bird Conservation Regions field protocol (McLaren et al. 2021). At each point, we recorded the date, time, percent cloud cover, wind speed according to the Beaufort scale, temperature (°C), and landcover within a 50 m radius. The landcover variables we measured included primary habitat type, percent cover and relative abundance of overstory and understory species, groundcover, and the mean height of overstory, grasses, and forbs (McLaren et al. 2021). We recorded all birds present at the point during a 6-minute survey. For each independently detected bird, we recorded the species, point number, the minute during the count in which it was detected, radial distance to the bird, and detection method. We did not include juveniles in the count because we were focused on adult breeding birds.

Ground-nesting Bird Nesting Success

Within the larger designated nest searching areas, we searched for horned lark nests during 2 seasons (March to July 2020−2021) and long-billed curlew nests during 3 field seasons (April to June 2019−2021). We found nests by observing behavioral cues,

such as territorial displays, courtship, nest building, and feeding behaviors. We also found nests incidentally by flushing birds off nests while walking through nest searching areas. During the initial visit to a nest, we recorded the location of the nest and the number of eggs or chicks, measured the developmental stage of eggs or chicks, and calculated a predicted hatch and fledge date. After the initial visit, we checked nests every 2 to 3 days from a distance to minimize disturbance. We detail our monitoring methods, including precautions we took to minimize our disturbance, in the Supporting Information. We monitored each nest until it failed, the eggs hatched (precocial long-billed curlews), or the chicks fledged (altricial horned larks). As the predicted hatch or fledge date approached, we checked nests daily to better determine nest fate. Within 7 days after the actual or predicted fledge (horned lark) or hatch (curlew) date, we conducted a habitat survey of the nest site. At each nest site, we surveyed the nest and collected data on habitat variables we wanted to study, including the percent of the nest that was concealed, if the nest was oriented toward vegetation, the number of terrestrial predator burrows in the territory, the number of conspicuous objects in 3 m of the nest, and the distance to the nearest road (Appendix C). Conspicuous objects included rocks and cowpies over 10 cm in diameter (Coates et al. 2019). We chose these measurements because conspicuous objects have been found to be positively related to curlew nesting success (Coates et al. 2019), nest concealment was a measure of protection from aerial and terrestrial predators, the number of predator burrows in the territory was a measure of predation pressure, nest orientation has been found to impact horned lark nest temperature (Nelson and Martin 1999), and the distance to the nearest road provided a measure of disturbance.

Analysis

We conducted our statistical analyses in R (R 4.1.2, RStudio 2022.02.0; R Core Team 2021). Because our goals were to test the hypothesis that recreational intensity is related to each level of the ecosystem and to compare recreational intensity to other variables, we created a single model for each ecological outcome with all predictor variables of interest. We tested predictor variables for multicollinearity and removed any with a correlation greater than 0.6 and, in these cases, retained the variable that was a higher priority in our hypotheses. To facilitate the comparison of effect sizes, we standardized each numeric variable by two standard deviations (Gelman 2008). We used a frequentist framework in our analyses and considered effect size, 95% confidence intervals, and P-values to determine the strength of evidence for the relationship of each model parameter and the outcome. We considered alpha values of 0.1 or greater to be little or no evidence, 0.05 to 0.1 to be weak evidence, 0.01 to 0.05 to be moderate evidence, and 0.01 or less to be strong evidence when considered with other factors listed (Muff et al. 2021).

Recreational Intensity

We used the locations of recreation observations from our driving surveys to map a Gaussian kernel density estimate of recreation intensity across the study site for each week of the study. Point density is a common tool used to show the spatial distribution of recreationists over a period (Riungu et al. 2018) and has been used to create a measure of hunting intensity to be used as a covariate (Dobbins et al. 2020). The kernel density estimate used a probability density function to explain the continuous process that gave rise to the point pattern of our recreation observations. The values we used for

recreational intensity in our analyses represent the intensity of the point process for recreational use observations and have no units. We assigned recreational intensity to each 1-km^2 site with the kernel density estimate of recreational use throughout the timeframe when we collected the full suite of ecological data (March–July 2021) within the site and a 500-m buffer. We tested the sensitivity of this estimate to buffer sizes from 500 m to 5000 m from the edge of each site in increments of 500 m and found that the estimate was the same for all buffer sizes and therefore chose the smallest buffer. To assign recreational intensity to horned lark and long-billed curlew nests, we used the recreational intensity within the territory over the weeks the nest was occupied. We used 100 m and 500 m from the nest site respectively for larks and curlews as a territory size based on the distance at which we expected each species to potentially be disturbed. We used the range of minimum to maximum kernel density estimates when plotting the predictions from statistical models to show the relationship between recreation intensity and each response variable.

Landcover Variables

We derived road density, powerline density, and percent developed landcover in QGIS (Version 3.16; QGIS Development Team 2022). We calculated road density within each 1-km^2 site using an up-to-date shapefile of roads in the NCA provided by the Idaho Army National Guard. We collected GPS points for powerline locations in the field, then created a shapefile. We summed the total distance (m) of roads or powerlines within a site, then divided by the site area (ha) to calculate the density variables. We calculated percent developed with the National Land Cover Database (Dewitz 2019). We combined all categories of developed land present at the site, which included roads and other

structures: ‘Developed, Open Space,’ ‘Developed, Low Intensity,’ and ‘Developed, Medium Intensity.’ No land categorized as ‘Developed, High Intensity’ was present.

Relationship of Recreational Intensity and the Dominant Prey Species

We used a binomial N-mixture model to test our predictions about the impacts of recreation intensity and other predictors on the abundance of a dominant prey species, Piute ground squirrels (‘unmarked’ package; Fiske and Chandler 2011, Kery and Royle 2021). We included date (day of year), time (min past sunrise), temperature (°C), wind (km/hr), and observer experience as predictors of detection probability in the binomial detection submodel. We included recreational intensity and the presence of shrubs in the Poisson abundance submodel that links abundance to environmental predictors at the site level. After testing the sensitivity of the model output to the value of the summation limit of individuals in a surveyed area, we used the default limit of 100 individuals more than the maximum observations at a site. We grouped observers into experienced and novice categories based on years of fieldwork at the site. We recorded the presence or absence of shrubs within the 1-ha ground squirrel survey plot during surveys and included shrub presence as a binary variable in the model. We evaluated the model using a parametric bootstrap goodness of fit test and a visual examination of the residual plots (Duarte et al. 2018, Mazerolle 2020).

Relationship of Recreational Intensity and Avian and Mammalian Scavengers

We used another binomial N-mixture model to test our predictions about the relationship of recreational use and other predictors on the abundance of raptors and ravens at each site. We created separate models for raptors and ravens because ravens are particularly adept at utilizing supplemental resources that humans leave on the landscape

(White 2005, Lafferty et al. 2016) and the number of raven observations was similar to the number of all raptor observations. We removed observations of birds outside of the 250 m buffer surrounding the site to ensure that our analysis captured individuals using the sites. We excluded observations of short-eared owls (*Asio flammeus*), which are not known to scavenge or prey on ground squirrels or ground-nesting bird nests. We also removed observations classified as unknown raptors. Our data included observations of flocks, which violated the assumption of the binomial N-mixture model that all individuals have the same detection probability because individuals in flocks are more likely to be detected. To be conservative, we counted each flock as one individual. We used species as a varying intercept and a varying slope with recreation intensity in the raptor model to account for species differences in abundance and response to recreation. We also included site as a varying intercept. We grouped ferruginous hawks (*Buteo regalis*), red-tailed hawks (*B. jamaicensis*), Swainson's hawks (*B. swainsoni*), and unidentified Buteo observations into a single category because they utilize similar prey and habitat at the study site. We included date (day of year), time (min past sunrise), wind (km/hr), and temperature (°C) as predictors of detection probability. In the abundance submodels, we included recreational intensity, ground squirrel abundance estimates, road density (m/ha), powerline density (m/ha), percent developed, and percent shrub cover as environmental predictors of raptor or raven abundance. We averaged percent shrub cover for each site using vegetation data from the breeding bird point counts.

We used a closed population capture-recapture analysis to estimate the density of badgers at each site ('Rcapture' package; Rivest and Baillargeon 2022). We used the

Wildlife Insights AI tool to separate blank trail camera captures from images with wildlife (Wildlife Insights Development Team 2021), then identified the observations to species. We compared the Wildlife Insights AI results to two cameras processed by our team to ensure that the AI tool was accurate. We split the deployment period (4 April to 16 July 2021) into 8 separate 2-week sampling occasions, the interval at which we reapplied scent bait to the traps. We used distinct facial patterns to identify individual badgers (Harrison 2016, Gould and Harrison 2018) and recorded each detection of an individual during a sampling occasion. To test our predictions about the relationship between recreational intensity and badger abundance, we compared the abundance of badger density at each site using a Poisson generalized linear model with recreational intensity, percent shrub cover, and percent developed as predictor variables ('stats' package; R Core Team 2021).

Relationship of Recreational Intensity and Ground-nesting Birds

We used distance sampling models to estimate horned lark and long-billed curlew density at each site ('Distance' package; Miller et al. 2019), then compared the effect of site-level variables on density estimates using a Poisson generalized linear model ('stats' package, R Core Team 2021) to test our predictions about the relationship of recreation on ground-nesting bird breeding density. After trying a hierarchical distance sampling approach and obtaining unreasonably large density estimates, we created separate distance sampling models for each species. We tested half-normal and hazard-rate key detection functions and selected half-normal for larks and hazard-rate for curlews based on a lower AICc value and goodness-of-fit test results. Our distance sampling models of detection probability contained date, time (min past sunrise), wind (km/hr), and

temperature (°C) as predictors, and our Poisson models of density contained recreational intensity, percent herbaceous cover, and percent shrub cover. We truncated detections at distances of 125 m for horned larks and 900 m for long-billed curlews.

We used Mayfield nest success estimates, which account for the number of days each nest was monitored, to estimate nesting success of long-billed curlews and horned larks (Mayfield 1961, 1975). We used a binomial generalized linear model with a logistic exposure link to test our predictions about the relationships of recreation and other predictors on daily nest survival rates ('stats' package; R Core Team 2021). This modeling method allowed us to account for the number of exposure days while assessing the impact of covariates on the probability of nest success (Hazler 2004, Shaffer 2004). The 2021 field season occurred during a drought and experienced unusually hot temperatures in the early summer (National Drought Mitigation Center 2021), so we included the 2021 season in our models of variables collected in multiple seasons. Our model of horned lark nesting success included recreational intensity, initiation date, nest orientation (presence/absence), and year as predictors. Our long-billed curlew nest success model included recreational intensity, the number of conspicuous objects within 3 m of the nest, and a factorial variable for the 2021 field season.

Results

Recreational Intensity at the Study Site

Recreational intensity varied greatly across the NCA with most use concentrated in the northern portions of the site (Figure 3.3). On the driving survey route in the highest use area, we observed 1 – 31 recreation groups/survey day ($\bar{x}$ = 9.73, SE = 6.05). On the lowest use route, we observed 0 – 2 recreation groups/survey day ($\bar{x}$ = 0.15, SE = 0.41).

Recreational use varied throughout the duration of the study and decreased during the especially hot June and July of 2021 relative to previous summers.

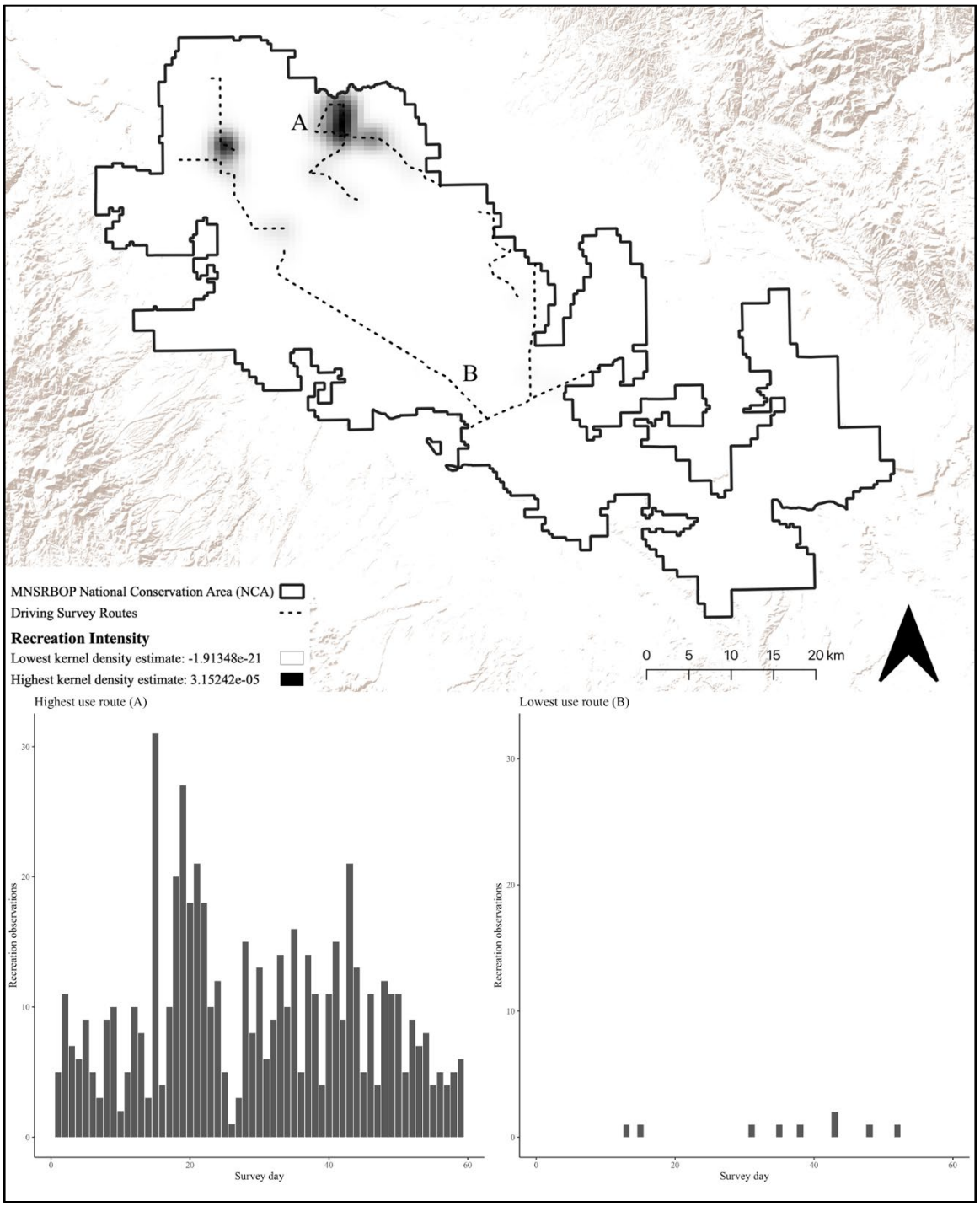

Figure 3.3. A kernel density plot of recreational intensity across the National Conservation Area for all types of recreation observed from April 2019 to July 2021. To help illustrate the wide range of recreational use we observed, we also show the number of recreation observations along the highest use route (A) and lowest use route (B) per survey day.

Relationship of Recreational Intensity and a Dominant Prey Species

We detected 0 − 33 Piute ground squirrels in a single survey (median = 2). Estimates of the abundance of ground squirrels produced by the binomial N-Mixture model varied from 15.45 ± 6.65 to 112.51 ± 17.90 ground squirrels/ha. Detection probability was 0.07 ± 0.56 at the mean value of all detection covariates ($\bar{x}_{date}$ = 29 May, $\bar{x}_{time}$ = 326 min past sunrise, $\bar{x}_{wind}$ = 18.7 km/hr, $\bar{x}_{temp}$ = 20.2 °C; Table 3.1).

There was strong evidence for a positive relationship between recreational intensity ($\beta = 0.81 \pm 0.27$, $P = 0.002$) and ground squirrel abundance. There was very strong evidence for a positive relationship between the presence of native shrub cover and the estimated abundance of ground squirrel ($\beta = 1.40 \pm 0.29$, $P \leq 0.001$). Estimated ground squirrel abundance at a site with mean recreational intensity (2.0×10^{-6}) was 20.55 ± 1.44 ground squirrels/ha with no shrub cover and 83.02 ± 14.92 ground squirrels/ha with shrub cover. When shrub cover was not present, estimated ground squirrel abundance increased by 42.67 ground squirrels/ha between the lowest (9.01×10^{-12}) and highest (9.47×10^{-6}) recreation intensity. When shrub cover was present, estimated ground squirrel abundance increased by 172.90 ground squirrels/ha (Figure 3.4).

Table 3.1. Parameter estimates for the abundance of Piute ground squirrel at sites in the Morley Nelson Snake River National Conservation Area in southwestern Idaho in 2021. Abundance was modeled using a binomial N-mixture model, and all parameters were scaled by two standard deviations.

Model parameters	*β*	95% CI	*Z*	*P*
Environmental submodel				
Intercept	3.02	2.30 to 3.74	8.23	≤ 0.001
Recreation intensity	0.81	0.29 to 1.34	3.03	0.002
Presence of shrub cover	1.40	0.83 to 1.97	4.81	≤ 0.001
Detection submodel				
Intercept	−2.60	−3.10 to −2.09	−10.12	≤ 0.001
Day of year	−0.71	−1.30 to −0.11	−2.33	0.020
Time (minutes past sunrise)	0.53	0.02 to 1.04	2.02	0.044
Wind (km/hr)	−1.45	−2.07 to −0.82	−4.53	≤ 0.001
Temperature (°C)	−0.56	−1.04 to −0.08	−2.30	0.022
Novice observer	−1.06	−1.76 to −0.36	−2.96	0.003

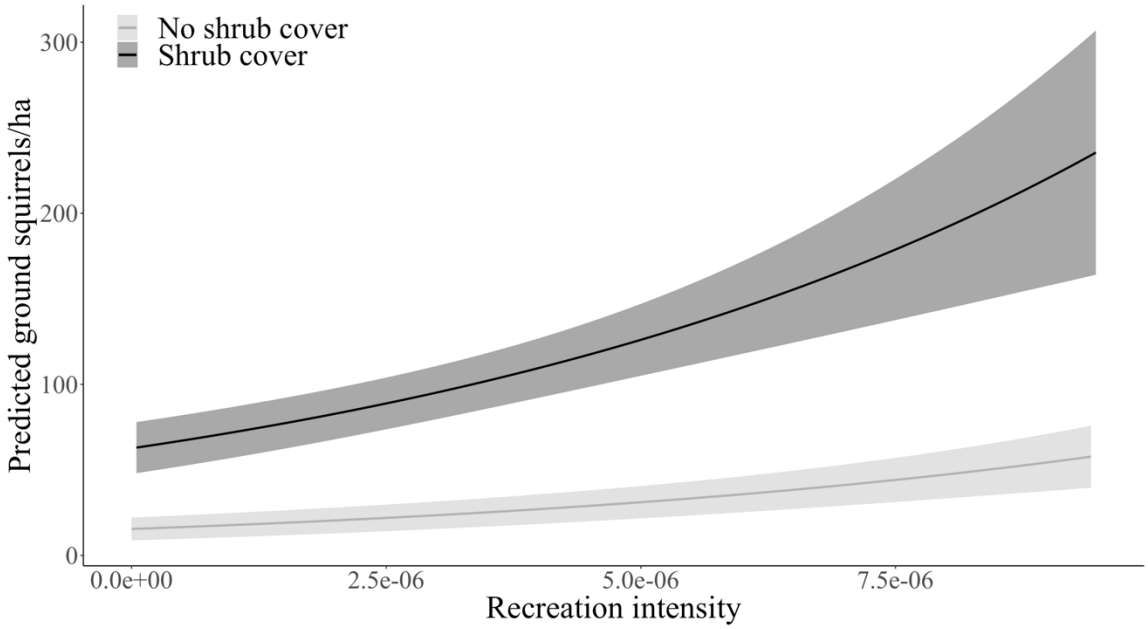

Figure 3.4. Predicted abundance of Piute ground squirrels plotted against recreational intensity at sites with and without shrub cover. Abundance was estimated using a binomial N-Mixture model that accounted for detection probability.

Relationship of Recreation on Avian and Mammalian Scavengers

Abundance of Avian Predators and Scavengers

Within the 250-m buffer around each 1-km^2 grid, we observed ravens (n = 185 observations), northern harriers (*Circus hudsonius*, n = 61), red-tailed hawks (n = 27), prairie falcons (*Falco mexicanus*, n = 21), burrowing owls (*Athene cunicularia*, n = 17), Swainson's hawks (n = 17), golden eagles (*Aquila chrysaetos*, n = 8), ferruginous hawks (n = 7), turkey vultures (*Cathartes aura*, n = 5), and short-eared owls (n = 3). We also briefly observed several birds that could not be identified beyond being raptors (n = 6) or members of the *Buteo* genus (n = 6). We observed 94 flocks (n = 86 raven flocks, n = 8 raptor flocks, median size = 2, range = 2−5 individuals), which were included in the analyses as one individual. We removed ground squirrel abundance estimates as a predictor variable due to high multicollinearity (0.74) with powerline density because our

estimates of ground squirrel abundance included error. We also removed road density, which had high multicollinearity (0.86) with percent developed, because percent developed was more comprehensive.

Raptor detections within the 250 m buffer ranged from 0 to 6 per survey ($\bar{x}$ = 0.37). Detection probability was 0.10 ± 0.57 when detection covariates were at their mean values ($\bar{x}_{date}$ = 20 June 2021, $\bar{x}_{time}$ = 400 min past sunrise, $\bar{x}_{wind}$ = 16.8 km/hr, $\bar{x}_{temp}$ = 23.6 °C; Table 3.2). There was little to no evidence of a relationship between recreational intensity and raptor abundance (β = 0.35 ± 0.45), as well as positive relationships with powerline density (β = 0.41 ± 0.38) and percent developed (β = 0.51 ± 0.40) and a negative relationship with percent shrub cover (β = −0.07 ± 0.39). There was moderate evidence for variance in raptor abundance between sites (σ_{Site} = 0.41 ± 0.27).

There was little to no evidence for differences in response to recreational intensity by raptor species ($\sigma_{Species|Recreation}$ = 0.45 ± 0.37), including no relationship between recreation and burrowing owls (β = 0.00 ± 0.65) and positive relationships between recreation and the abundance *Buteo* species (β = 0.36 ± 0.43), golden eagles (β = 0.35 ± 0.54), northern harriers (β = 0.24 ± 0.45), prairie falcons (ß = 0.70 ± 0.51), and turkey vultures (β = 0.44 ± 0.51). There was strong evidence for variance in raptor abundance between species at the NCA ($\sigma_{Species}$ = 1.03 ± 0.38), including strong evidence for higher abundance of the *Buteo* species (β = 1.75 ± 0.32) and northern harriers (β = 1.82 ± 0.33) relative to the all-species mean abundance. There was moderate evidence for higher baseline abundance of burrowing owls (β = 0.43 ± 0.42) and prairie falcons (β = 0.68 ± 0.40), and lower baseline abundance of turkey vultures (β = −0.16 ± 0.47) and golden eagles (β = −0.02 ± 0.43).

Predicted raptor abundance was 2.06 ± 1.72 raptors/km^2 at mean site-level parameter values ($\bar{x}_{rec}$ = 2.0 x 10^{-6}, $\bar{x}_{ppl}$ = 2.40 m/ha, $\bar{x}_{dev}$ = 0.63%, $\bar{x}_{shrub}$ = 4.77%). Estimated raptor abundance increased by 6.59 raptors/km^2 between the lowest (9.01x10^{-12}) and highest (9.47x10^{-6}) recreational intensity, decreased by 0.69 raptors/km^2 over the range of shrub cover (0.00 - 11.56%), increased by 3.37 raptors/km^2 across the range of powerline density (0.00 - 5.74 m/ha), and increased by 5.15 raptors/km^2 across the range of percent developed (0.00 - 3.57%; Figure 3.5).

Table 3.2. Parameter estimates for the abundance of raptor species at sites in the Morley Nelson Snake River National Conservation Area in southwestern Idaho in 2021. Abundance was modeled using a binomial N-Mixture model, and all parameters were scaled by two standard deviations.

Model Parameters	β	95% CI	Variance
Environmental submodel			
Intercept	0.72	−0.37 to 1.68	
Recreation	0.35	−0.61 to 1.27	
Powerline density (m/ha)	0.41	−0.32 to 1.24	
% Developed	0.51	−0.25 to 1.54	
% Shrub cover	−0.07	−0.87 to 0.65	
Site varying intercept			0.41 ± 0.27
Species varying intercept			1.03 ± 0.38
Species x recreation varying slope			0.45 ± 0.37
Detection submodel			
Intercept	−2.16	−2.68 to −1.63	
Date (day of year)	−0.49	−0.95 to −0.06	
Time (minutes past sunrise)	−0.08	−0.55 to 0.38	
Wind (km/hr)	0.12	−0.24 to 0.45	
Temperature (°C)	−0.08	−0.59 to 0.43	
Site varying intercepts			
High 1	0.72	−0.76 to 1.89	
Low 1	0.65	−0.82 to 1.83	
High 2	0.71	−0.72 to 1.97	
Low 2	1.14	−0.08 to 2.30	
High 3	0.55	−0.81 to 1.76	

Low 3	0.56	−0.75 to 1.65
High 4	0.77	−0.47 to 1.87
Low 4	0.55	−0.83 to 1.65
High 5	0.77	−0.39 to 2.07
Low 5	0.78	−0.39 to 1.91
Species varying intercepts		
Burrowing owl	0.43	−0.53 to 1.21
Buteo	1.75	1.10 to 2.37
Golden eagle	−0.02	−0.95 to 0.78
Northern harrier	1.82	1.19 to 2.41
Prairie falcon	0.68	−0.14 to 1.43
Turkey vulture	−0.16	−1.10 to 0.66
Species varying slopes		
Burrowing owl	0.00	−1.62 to 1.01
Buteo	0.36	−0.51 to 1.27
Golden eagle	0.35	−0.79 to 1.40
Northern harrier	0.24	−0.76 to 1.04
Prairie falcon	0.70	−0.27 to 1.72
Turkey vulture	0.44	−0.61 to 1.50

Raven detections within the sites ranged from 0 to 17 ravens per survey ($\bar{x}$ = 3.79). Detection probability was 0.12 ± 0.60 at the mean value of all detection coefficients ($\bar{x}_{date}$ = 20 June 2021, $\bar{x}_{time}$ = 400 min past sunrise, $\bar{x}_{wind}$ = 16.8 km/hr, $\bar{x}_{temp}$ = 23.6 °C; Table 3.3). There was strong evidence that recreational intensity had a positive relationship with estimated raven abundance (β = 0.65 ± 0.16, $P \leq 0.001$) and

moderate evidence of a positive relationship between estimated raven abundance and powerline density ($\beta = 0.37 \pm 0.17$, $P = 0.029$) and percent developed ($\beta = 0.37 \pm 0.16$, $P = 0.020$). There was no evidence of a relationship between percent shrub cover and estimated raven abundance ($\beta = -0.10 \pm 0.20$, $P = 0.627$).

Estimated raven abundance was 24.86 ± 1.41 ravens/km^2 at the mean value of all environmental covariates ($\bar{x}_{rec} = 2.0 \times 10^{-6}$, $\bar{x}_{ppl} = 2.40$ m/ha, $\bar{x}_{dev} = 0.63\%$, $\bar{x}_{shrub} = 4.77\%$). Estimated raven abundance increased by 37.65 ravens/km^2 across the range of recreational intensity values (9.01×10^{-12} - 9.47×10^{-6}), 11.97 ravens/km^2 across the range of powerline density values (0.00 - 5.74 m/ha), 15.47 ravens/km^2 across the range of percent developed values (0.00 - 3.57%; Figure 3.5) and decreased by 4.14 ravens/km^2 across the range of shrub cover present (0.00 - 11.56%).

Table 3.3. Parameter estimates for the abundance of common ravens at sites in the Morley Nelson Snake River National Conservation Area in southwestern Idaho in 2021. Abundance was modeled using a binomial N-Mixture model, and all parameters were scaled by two standard deviations.

Model Parameters	*β*	95% CI	*Z*	*P*
Environmental submodel				
Intercept	3.21	2.54 to 3.89	9.34	≤ 0.001
Recreation intensity	0.65	0.33 to 0.97	3.96	≤ 0.001
Powerline density (m/ha)	0.37	0.04 to 0.69	2.19	0.029
% Developed	0.37	0.06 to 0.69	2.33	0.020
% Shrub cover	−0.10	−0.49 to 0.30	−0.49	0.627
Detection submodel				
Intercept	−1.98	−2.78 to −1.19	−4.89	≤ 0.001
Date (day of year)	−0.66	−1.01 to −0.31	−3.71	≤ 0.001
Time (minutes past sunrise)	0.46	0.09 to 0.82	2.43	0.015
Wind (km/hr)	−0.40	−0.68 to −0.12	−2.83	0.005
Temperature (°C)	−0.81	−1.23 to −0.40	−3.82	≤ 0.001

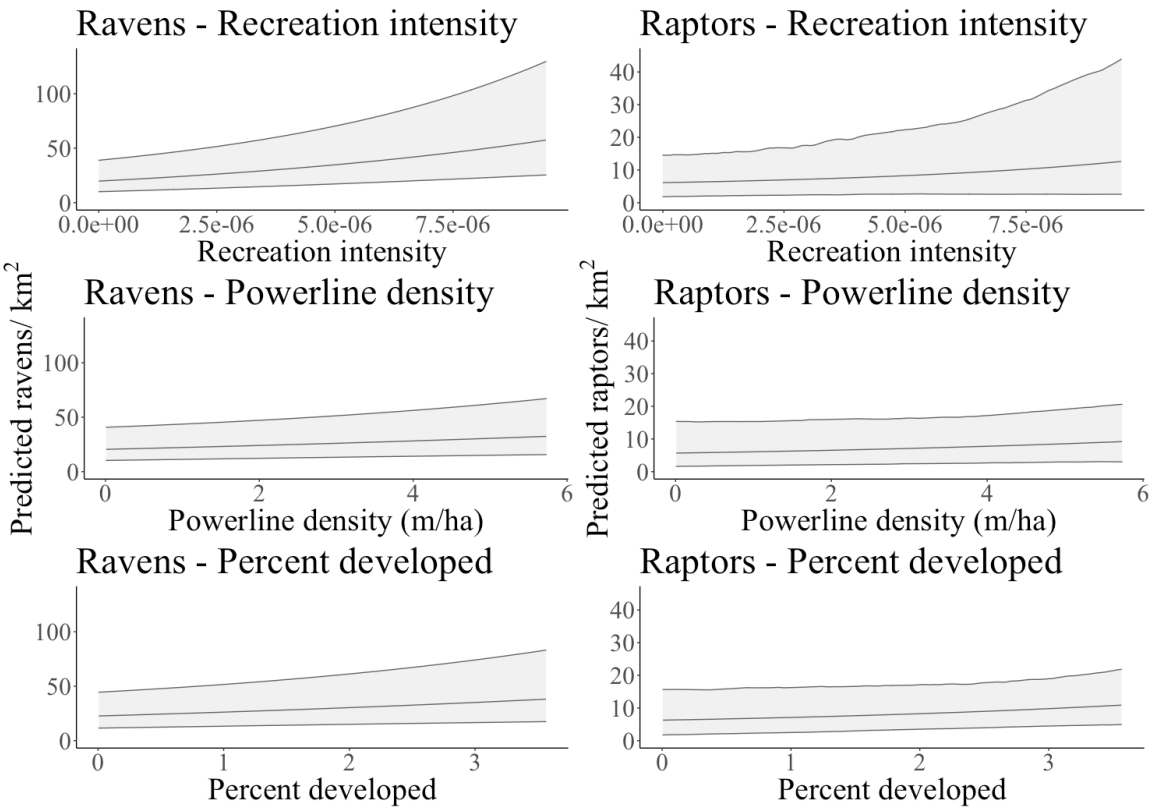

Figure 3.5. Predicted abundance of common ravens and raptors across a range of recreation intensity, powerline density, and percent developed. All fixed effects were held at the mean value. Raptor abundance was predicted using the mean value of the varying slope and intercepts.

Abundance of a Mammalian Predator

Over 1,960 camera days, we captured 125 visits from badgers (6.4 visits per 100 camera-days). Of these detections, 73 photos could be used to identify individuals, and we identified a total of 23 individual badgers with the useable photos.

Estimated badger abundance ranged from 0 to 7 badgers/km^2 ($\bar{x}_{rec} = 2.0 \times 10^{-6}$, $\bar{x}_{ppl} = 2.40$ m/ha, $\bar{x}_{dev} = 0.63\%$). There was strong evidence for a positive relationship between recreational intensity and badger abundance ($\beta = 1.13 \pm 0.35$, $P = 0.002$) and no evidence for a relationship between badger abundance and percent shrub cover ($\beta = -0.66 \pm 0.57$, $P = 0.239$), percent developed ($\beta = -1.37 \pm 0.94$, $P = 0.147$) or ground squirrel abundance ($\beta = -0.42 \pm 0.49$, $P = 0.394$; Table 3.4).

Estimated badger abundance at a site with average recreation, shrub cover, and percent developed was 1.81 ± 1.34 badgers/km^2. Estimated badger abundance increased by 6.03 badgers/km^2 across the range of recreational intensity values ($9.01x10^{-12}$ to $9.47x10^{-6}$). Across the range of shrub cover (0.0 to 11.6%), estimated badger density decreased by 1.89 badgers/km^2. Estimated badger abundance decreased by 2.08 badgers/km^2 across the range of percent developed (0.05 to 3.57%). Badger density was estimated to decrease by 1.04 badgers/km^2 across the range of ground squirrel abundance (15.5 to 112.5 squirrels/ha; Figure 3.6).

Table 3.4. Parameter estimates for badger abundance at the Morley Nelson Snake River National Conservation Area in southwestern Idaho in 2021. Site-level abundance was estimated with a closed population capture-recapture model, then compared with a Poisson model of abundance. All parameters were scaled by two standard deviations.

Model Parameters	*ß*	95% CI	*Z*	*P*
Intercept	0.59	−0.13 to 1.08	2.04	0.041
Recreation intensity	1.13	0.43 to 1.86	3.17	0.002
% Shrub cover	−0.67	−1.92 to 0.34	−1.45	0.147
% Developed	−1.37	−4.10 to 0.08	−1.45	0.147
Ground squirrel abundance	−0.42	−1.43 to 0.52	−0.85	0.395

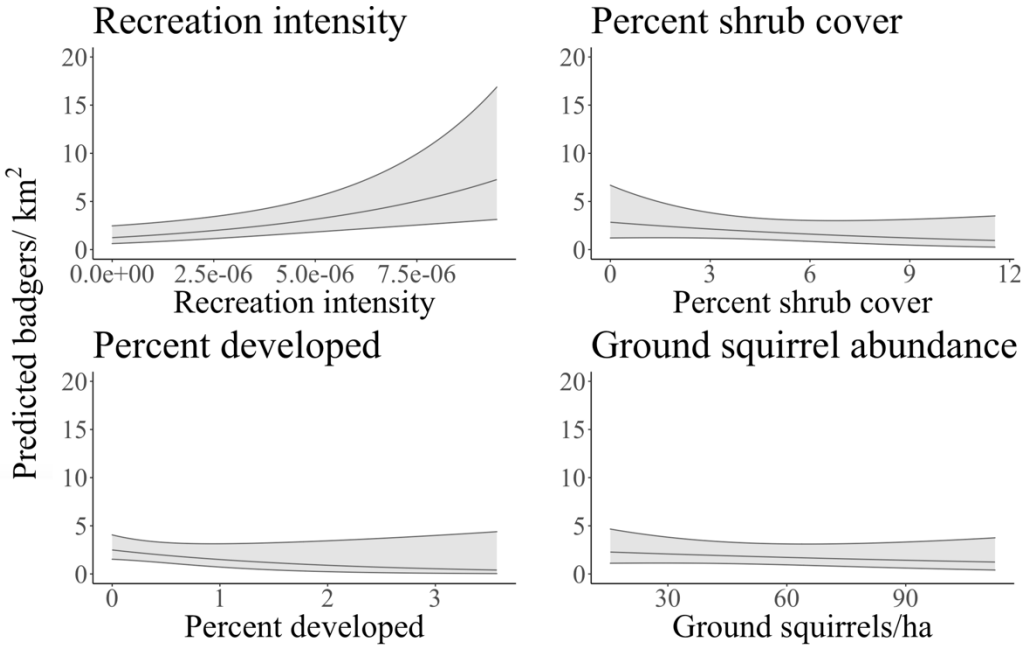

Figure 3.6. Predicted abundance of badgers across a range of recreation intensity (A), percent developed (B), percent shrub cover (C), and ground squirrel abundance with all other variables held at their mean value.

Relationship of Recreation and Ground-nesting Birds

Breeding Density

Horned lark detections across the 10 sites ranged from 1 to 64 larks/km^2. The mean detection probability was 0.64 ± 0.09. There was very strong evidence of negative relationships between the breeding density of horned larks and recreational intensity (β = −0.66 ± 0.12, $P \leq 0.001$) and shrub cover (β = −0.67 ± 0.15, $P \leq 0.001$) and a positive relationship between horned lark density and herbaceous cover (β = 0.47 ± 0.08, $P \leq$ 0.001; Table 3.5).

Estimated horned lark density was 44.33 ± 1.05 larks/km^2 at the mean value of all site-level parameters ($\bar{x}_{rec}$ = 2.0 x 10^{-6}, $\bar{x}_{shrub}$ = 6.24%, $\bar{x}_{herb}$ = 7.12%). Estimated horned lark density decreased by 35.5 larks/km^2 across the range of recreational intensity (9.0 x 10^{-12} to 9.5 x 10^{-6}), decreased by 37.0 larks/km^2 across the range of shrub cover

(0% to 30%), and increased by 41.9 larks/km^2 across the range of herbaceous cover (0.1% to 29.4%; Figure 3.7).

Table 3.5. Parameters estimates for horned lark density at the Morley Nelson Snake River National Conservation Area in southwestern Idaho in 2021. Density was modeled using a distance sampling model, then compared between sites with a Poisson generalized linear model. All parameters were scaled by two standard deviations.

Model Parameters	β	SE	Z	P
Density Poisson model				
Intercept	3.79	0.05	74.21	≤ 0.001
Recreation intensity	−0.66	0.12	−5.28	≤ 0.001
% Shrub cover	−0.67	0.15	−4.41	≤ 0.001
% Herbaceous cover	0.47	0.08	6.17	≤ 0.001
Distance sampling model				
Intercept	5.25	0.71		
Date (day of year)	0.19	2.68		
Time (minutes past sunrise)	0.24	0.35		
Temperature (°C)	1.37	0.76		

Long-billed curlew detections ranged from 0 to 59 curlews/km^2. The average detection probability was 0.33 ± 0.06. There was moderate evidence for a positive relationship between curlew density and percent of herbaceous cover (β = 1.3 ± 0.57, P = 0.022), no evidence for relationship between curlew density and recreational intensity (β = 0.39 ± 0.54, P = 0.476) or shrub cover (β = −0.78 ± 0.66, P = 0.237; Table 3.6).

Estimated long-billed curlew density was 1.56 ± 1.31 curlews/km^2 at the mean value of all density submodel parameters ($\bar{x}_{rec}$ = 2.0 x 10^{-6}, $\bar{x}_{shrub}$ = 6.24%, $\bar{x}_{herb}$ =

7.12%). Estimated curlew density increased by 6.65 curlews/km^2 across the range of herbaceous cover (0.1% to 29.4%), increased by 1.15 curlews/km^2 across the range of recreational intensity (9.0 x 10^{-12} to 9.5 x 10^{-6}), and decreased by 1.47 curlews/km^2 across the range of shrub cover (0% to 30%; Figure 3.7).

Table 3.6. Parameter estimates for long-billed curlew density at the Morley Nelson Snake River National Conservation Area in southwestern Idaho in 2021. Density was modeled using a distance sampling model, then compared between sites with a Poisson generalized linear model. All parameters were scaled by two standard deviations.

Model Parameters	*ß*	SE	*Z*	*P*
Density Poisson model				
Intercept	0.44	0.27	1.66	0.097
Recreation intensity	0.39	0.54	0.713	0.476
% Shrub cover	−0.78	0.66	−1.18	0.237
% Herbaceous cover	1.30	0.57	2.28	0.022
Distance sampling model				
Intercept	5.77	0.15		
Date (day of year)	−0.31	0.52		
Time (minutes past sunrise)	−0.14	0.20		
Temperature (°C)	−0.62	0.50		
Hazard-rate (scale)	1.07	0.21		

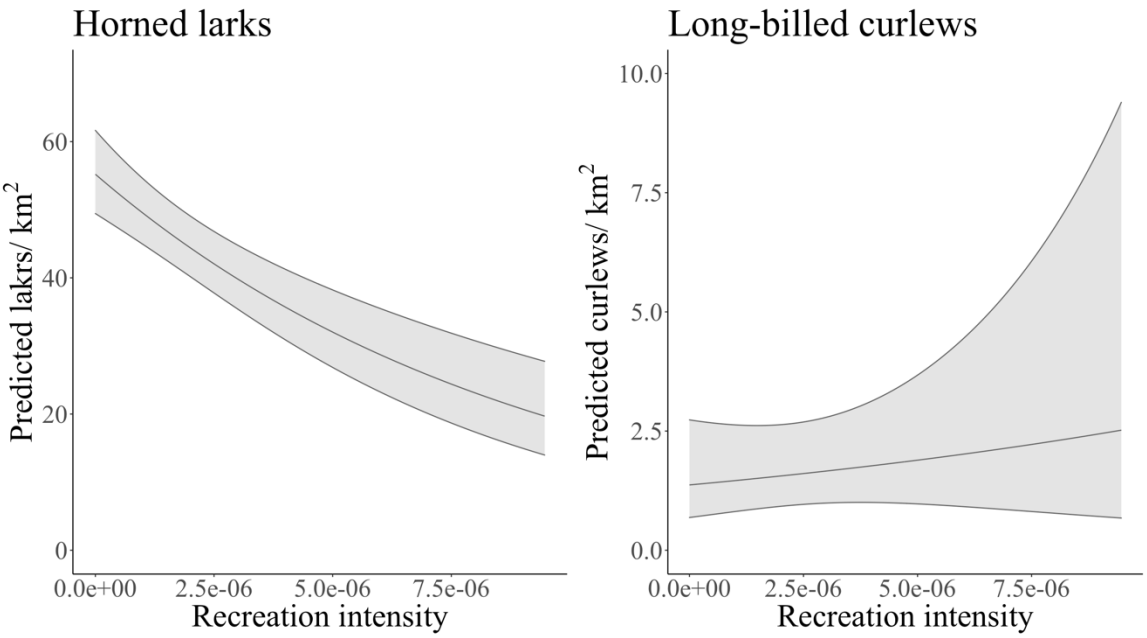

Figure 3.7. Predicted density of horned larks and long-billed curlews across a range of recreation intensity, percent herbaceous cover, and percent shrub cover. Density across the range of herbaceous cover and shrub cover was predicted using the minimum, mean, and maximum recreation intensity. All other variables were held at their mean value.

Nesting Success

We found a total of 102 horned lark (n_{2020} = 43, n_{2021} = 59) and 95 long-billed curlew (n_{2019} = 32, n_{2020} = 35, n_{2021} = 28) nests that were occupied. Mayfield nest success estimates for long-billed curlews at the NCA varied from 0.83%to 34.96% but were consistently lower in the higher recreation site (Table 3.7). Horned lark nest success estimates ranged from 9.68 to 24.01% and were lower in the high recreation site during both seasons. However, the difference between high and low recreation sites for horned larks was much more pronounced in 2020.

Table 3.7. Mayfield nest success estimates for long-billed curlews and horned larks at high and low recreational use sites in southwestern Idaho from 2019 to 2021.

	2019		2020		2021	
Species	High Rec.	Low Rec.	High Rec.	Low Rec.	High Rec.	Low Rec.
Long-billed curlews	33.69% (n = 11)	34.96% (n = 21)	18.23% (n = 16)	32.06% (n = 19)	0.83% (n = 11)	6.06% (n = 17)
Horned larks			13.95% (n = 18)	24.01% (n = 25)	9.68% (n = 26)	10.78% (n = 33)

We detected no evidence for relationships of horned lark nesting success with recreational intensity ($\beta = -0.42 \pm 0.36$, $P = 0.240$), later initiation dates ($\beta = -0.47 \pm 0.35$, $P = 0.181$), or nest orientation to vegetation or other structures (ß = 0.19 ± 0.46, $P = 0.672$; Table 3.8). There was no relationship between the year of the study and horned lark nesting success ($\beta = -0.30 \pm 0.35$, $P = 0.392$).

The estimated probability of horned lark nesting success for a nest with average values for recreational intensity ($\bar{x} = 1.1\text{x}10^{-6}$), initiation date ($\bar{x}$ = May 19), and orientation in the 2020 season was 0.86 ± 0.60. The 2021 breeding season decreased the probability of nesting success by 57.4%. As recreational intensity increased from lowest value ($1.5\text{x}10^{-10}$) to its highest ($9.0\text{x}10^{-6}$), the estimated probability of nest success declined by 16.4% (Figure 3.8). Increasing initiation date from the earliest observed (April 1) to the latest (July 11) decreased the probability of nest success by 10.2%. Nests that were oriented, or adjacent, to vegetation or another object had a 45.2% higher probability of nest success.

Table 3.8. Model parameter estimates for a generalized linear model with a logistic exposure link of horned lark nesting success in southwestern Idaho in 2020 and 2021. All parameters were scaled by two standard deviations.

Model Parameters	β	95% CI	Z	P-value
Intercept	1.79	1.06 to 2.60	4.22	≤ 0.001
Recreation	−0.42	−1.13 to 0.28	−1.17	0.240
Initiation date	−0.47	−1.07 to 0.10	−1.34	0.181
Orientation present	0.19	−0.65 to 1.00	0.42	0.672
Year (2021)	−0.30	−0.89 to 0.28	−0.89	0.392

The probability of long-billed curlew nesting success decreased with recreational intensity ($\beta = -17.44 \pm 6.04$, $P \leq 0.001$) and in the 2021 nesting season ($\beta = -1.24 \pm 0.47$, $P \leq 0.001$; Table 3.9). There was strong evidence for both of these relationships and the negative association with recreation was much larger than any other effect in the model. There was little to no evidence of a slight positive relationship with the number of conspicuous objects within 3 m of the nest ($\beta = 0.04 \pm 0.33$, $P = 0.890$).

The estimated probability of long-billed curlew nesting success for a nest with average recreational intensity ($\bar{x} = 1.3\text{x}10^{-6}$) and conspicuous objects ($\bar{x} = 8.4$), and not occurring during the 2021 season, was 0.27 ± 0.81. The 2021 breeding season decreased the probability of nesting success by 77.6%. As recreation increased from lowest value ($2.2\text{x}10^{-16}$) to its highest ($4.0\text{x}10^{-6}$), the estimated probability of nest success declined by 99.5% (Figure 3.8). As the number of conspicuous objects within 3 m of the nest increased from 0 to 75, the probability of curlew nest success increased by 2.8%.

Table 3.9. Model parameters for a generalized linear model with a logistic exposure link of long-billed curlew nesting success in southwestern Idaho from 2019 to 2021. All parameters were scaled by two standard deviations.

Model Parameters	*ß*	95% CI	*Z*	*P*
Intercept	−1.00	−2.46 to 0.46	−0.681	0.50
Recreation intensity	−17.44	−23.48 to −11.40	−2.89	≤ 0.001
Year (2021)	−1.24	−1.71 to −0.77	−2.67	≤ 0.001
Conspicuous objects	0.04	−0.29 to 0.37	0.136	0.890

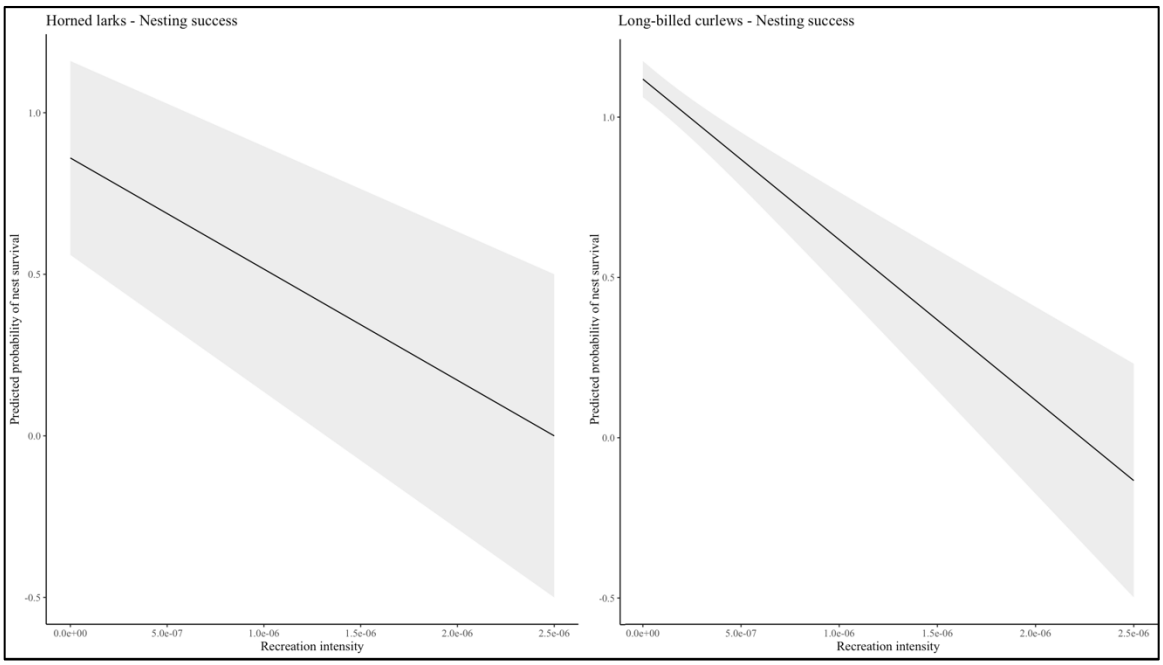

Figure 3.8. Predictive plots for the probability of horned lark nesting and long-billed curlew nest success across a range of recreation intensity values with all other variables held at their mean value.

Discussion

We found evidence of relationships between recreational use and multiple levels of the sagebrush-steppe ecosystem, and the relationships varied in direction and magnitude across the levels of the ecosystem included in our study. The abundance of

Piute ground squirrels, a dominant prey species, had a positive relationship with recreational use, but native shrub cover had a much larger positive association with abundance. The abundance of avian predators and scavengers was positively related to higher recreational use, but the relationship was stronger for ravens than any of the raptor species included in the study. The abundance of badgers, a common mammalian predator and scavenger in the system, was positively related to recreational use. Ground-nesting birds were negatively associated with recreation, but relationships differed between the two species. Horned lark breeding density was negatively associated with recreational use, while long-billed curlew density was not related to recreational intensity. Conversely, the nest success of long-billed curlews had a strong negative relationship with recreational intensity, while horned lark nesting success was not significantly related to recreational intensity. Considering these results gives an indication of how recreation is interacting with and potentially impacting the wildlife in this ecosystem relative to other factors.

The positive relationship between recreational intensity and Piute ground squirrel abundance did not support our hypothesis that abundance would be lower due to direct mortality, but it could suggest that recreational shooters select sites with more ground squirrels. It is important to point out that our study only captured one year of site-level variation in ground squirrel abundance, and the 2021 field season was an unusually low year for the ground squirrel populations at the NCA (J. Cruz, Boise State University, and Z. Duran, Idaho Army National Guard, personal communication). Populations of Piute ground squirrels at the NCA are known to vary from 1.8 to 2.67-fold between their minimum and maximum state (Yensen et al. 1992), so additional years of data could

confirm if these trends hold when ground squirrel populations are higher. There is some evidence that recreational shooting does not lead to long-term population declines in other small mammals that are targeted (Black-tailed prairie dog, *Cynomys ludovicianus*, Vosburgh and Irby 1998), which would be consistent with the lack of a negative response we observed here.

There may be factors we did not measure here that make a site suitable for both ground squirrels and recreationists. Recreationists report that they select sites for shooting based on the number of ground squirrels and open landcover that makes it possible to see squirrels (M. Aberg, Boise State University, unpublished data), although it is unclear how accurately they assess ground squirrel abundance while considering potential sites and how shrub cover plays into their decision. If recreational shooters can assess ground squirrel abundance with some accuracy or if they return to sites with high abundance, the positive association with recreational use may be due to ground squirrels attracting recreational users.

The estimated effect size for presence of shrub cover on estimated ground squirrel abundance was nearly twice the size for the predictor describing intensity of recreational use. Ground squirrels at the NCA are thought to be food-limited, which may contribute to population fluctuations (Yensen et al. 1992). During periods of low ground squirrel abundance, areas with shrub cover, particularly big sagebrush or winterfat (*Krascheninnikovia lanata*), tend to have more stable populations because native vegetation provides a more consistent food source (Yensen et al. 1992, Steenhof et al. 2006). In the year we collected data, when ground squirrel abundance was low and drought ongoing, the consistent food source provide by native shrubs may have

contributed to the higher ground squirrel abundance that we observed in sites with shrub cover.

Avian predators and scavengers differed in their response to recreational use. We expected that the carcasses left behind by recreational shooting would attract scavengers to the area, leading to a positive relationship between recreation and scavenger abundance. The strong response of ravens to recreation is consistent with findings that the species is adept at using resources left on the landscape by humans and recognizing the presence of humans as a signal of potential resources (White 2005, Bui et al. 2010, Lafferty et al. 2016, McTee et al. 2019, Herring et al. 2021). There may also be indirect effects of recreational use being associated with major roads (Pauli et al. 2019), which are near transmission lines at the NCA, potentially providing nesting and roosting habitat for ravens (Knight and Kawashima 1993, Steenhof et al. 1993). However, frequent overhead flights by larger groups of ravens suggest that ravens commuting from more distant roost sites, likely subadults based on group size (Marzlufi and Heinrich 1991), make up a large portion of ravens at the site. Raptor abundance and response to recreation varied by species with the most important variation being in the baseline differences in abundance between species at the NCA. *Buteo* species and northern harriers had higher abundance at all sites relative to the all-species mean. Recreation had no little to no relationship with the abundance of all raptor species. Other studies have also found variations between raptor species in ability to use supplemental resources (Lafferty et al. 2016, Mctee et al. 2019, Herring et al. 2021), which might contribute to differences in response to recreation in this system.

Our study examined the number of raptors and ravens using a site, particularly for foraging, regardless of whether or not the birds we observed were breeding in the area. Recreation at the site may provide an easily accessible food source for ravens and raptors, either by OHV riders flushing prey from hiding spaces or with carcasses left after a shooting event (Mctee et al. 2019, Herring et al. 2021). However, there may be drawbacks to using sites with high recreational use that our study did not address. Supplemental carcasses contain lead fragments, which can negatively impact scavenging birds and their nestlings (Herring et al. 2016, 2021, Mctee et al. 2019). Recreation may also disturb locally breeding pairs of raptors and ravens (Spaul and Heath 2017) or decrease nesting success (Martínez-Abraín et al. 2010, Steenhof et al. 2014), making areas with high recreational use less suitable for nesting even if they do attract raptors and ravens for foraging.

Our results were consistent with our expectation that badgers, like other potential predators of ground squirrels and scavengers of carcasses, would be attracted to areas with more recreational use. However, badgers are a legal and popular target of recreational shooting, so it is possible that the number of badgers killed in areas with high recreational use at the NCA counteracts the increased abundance from badgers being attracted to the area. In this case, the number of badgers killed by recreationists did not negate the positive association with recreation. It is also possible that our study did not measure all the variables that are relevant to badger habitat use. For example, studies of badger density in a desert habitat have found that soil depth and composition are important factors (Gould and Harrison 2018).

Horned larks were more abundant than long-billed curlews across our study area, but they co-occurred extensively. Horned lark density was negatively related to recreation and shrub cover that we detected, whereas long-billed curlew density was not related to these factors. The breeding density of both ground-nesting species was positively associated with the percent of herbaceous cover at a site. The negative relationship between the breeding densities of ground-nesting species and shrub cover was expected given that both species are known to prefer open ground for nesting sites (Coates et al. 2019, Beason 2020, Dugger and Dugger 2020). Decreased breeding densities of horned larks are consistent with the impact of recreation in studies examining the density of breeding birds near hiking and mountain biking trails, which have also found negative relationships between breeding density and recreational use (Miller et al. 1998, Fernandez-Juricic 2000, Thompson 2015). Ground-nesting species are particularly susceptible to disturbance from passing recreationists and increased predation, which can decrease the suitability of nest sites in these areas or lead to lower nesting success (Miller et al. 1998). The lack of a negative relationship between the density long-billed curlews and recreation may be due to a combination of high breeding territory fidelity and longer individual life spans in the species that leads to birds continuing to occupy and nest in suboptimal sites (Coates 2018). For example, if recreation intensity changes dramatically over a 10-year period, occupants of horned lark territories might have turned over several times while the same adult curlew with strong site fidelity might persist even as conditions become less suitable.

Horned larks and long-billed curlews at the NCA have consistently lower nesting success than populations monitored in similar habitats at other sites with no recreational

use (Camfield et al. 2010, Coates et al. 2019). Being conspicuous puts curlews at risk of being illegally shot, which occurs with a high degree of overlap with legal recreational shooting (Katzner et al. 2020). Curlews continuing to breed in areas with high recreational use may also contribute to this negative outcome, whereas horned larks appear to avoid heavily used areas to some extent. These results suggest that there are differences in response to recreational use, even among breeding birds with similar habitat use and nest predators, and that the reproductive success of species of conservation concern may be particularly impacted by recreational disturbance.

Our results may have been impacted by drought and extreme heat during the 2021 field season. High temperatures may have affected ecological outcomes we measured, particularly nesting success during the latter part of the breeding season in June and early July. During the period of abnormally high temperatures, recreational use decreased, potentially reducing disturbance of wildlife. Our use of a spatially and temporally informed recreation covariate helped to account for this change in recreational pressure to some extent. This highlights the importance of considering how changes in climate conditions might interact with recreation to affect public lands and the ecosystems they protect. As climatic conditions change, public land visitation is expected to decline in the summer and shift to the winter and spring (Wilkins et al. 2021). In the sagebrush-steppe ecosystem in southwestern Idaho, this predicted shift would result in more recreational users during the peak breeding season for ground squirrels, raptors, ravens, and ground-nesting birds at the site. As our understanding of the impacts of recreational use on the sagebrush-steppe ecosystem develops, we need to continue to account for the dynamic nature of recreation (Beeco and Brown 2013, Riungu et al. 2018, Peterson et al. 2020).

Another changing dynamic of recreation is the number and type of users living close to public lands throughout Idaho and the western United States. We found that the relationship of recreation and ecological outcomes varied with the intensity of recreational use. Without management interventions, more people on public lands are likely to increase the intensity of impacts. Growth in recreation driven by new residents brings more novice users to a site (McCool 2022). Novice recreationists use recreation areas differently than experienced users, leading to changes in the spatial and temporal extent and intensity of impacts (Frey et al. 2018). Recreation dynamics may also be affected by events like the COVID-19 pandemic, which led to more people recreating close to their residence and further increased recreation on public lands that are easily accessible from urban areas (Hockings et al. 2020, Landry et al. 2021). These factors outside of a conservation area may impact the intensity and spatiotemporal patterns of recreational use at a site and the resulting relationships with ecological outcomes.

Management Implications

Our study provides an initial assessment of patterns in abundance and reproductive success of species at multiple levels of the ecosystem. We suggest that managers should continue to monitor the amount of recreational use at the site, as higher levels of use will likely increase effects on ecological outcomes and consider ways to mitigate higher levels of recreation to ensure wildlife populations can persist. Long-billed curlews, a species of conservation concern in Idaho, had dramatically lower nesting success in areas with higher recreational intensity. Restricting recreational use in important habitat during the breeding season may help to reduce negative population impacts for this sensitive species. Indirect strategies to limit use in sensitive areas could

also be implemented, including providing recreation infrastructure in alternative areas, increasing management presence in sensitive areas, or informing visitors of problem areas (Marion 2019). Managing the spatial and temporal patterns of recreation could help to support species of conservation concern and promote the coexistence of recreation and conservation in sagebrush-steppe ecosystems.

CONCLUSIONS

Outdoor recreational use is increasing on many public lands, particularly in the western United States, which makes the balance of recreational opportunities and conservation challenging. Understanding and managing the complex system of outdoor recreation on public lands requires consideration of the social and ecological systems (Morse 2020, Miller et al. 2021, McCool 2022). I used a Coupled Human and Natural Systems (CHANS) approach to study the social and ecological impacts of recreational use, particularly recreational shooting, at a National Conservation Area (NCA) in southwest Idaho (Liu et al. 2007, Carter et al. 2014). I examined the spatiotemporal patterns of recreational use at the site (Chapter 1); interviewed recreationists, managers, and biologists to better understand the social system (Chapter 2); and assessed the effect of recreation on ecological outcomes at multiple levels of the sagebrush-steppe ecosystem (Chapter 3). Together, these results help us begin to build an understanding of feedbacks within and between the human and natural systems of recreation on this NCA and other public lands.

Feedbacks within the Human System

Recreational shooters, including people shooting targets and individuals hunting unprotected mammals, made up over 80% of observed recreational use at the NCA and drove overall patterns of use. As the largest group of recreationists at the NCA, individual shooters and their choice of sites could drive patterns of use and impacts. Recreational shooters used social conditions, specifically the presence of other users, to select shooting

sites (Chapter 1). Because the NCA has little recreation infrastructure, such as signs or trails, recreational shooters also used unofficial affordances to select sites, including the presence of trash and other signs of previous use (Chapter 1, Chapter 2).

Feedbacks within the social system were also evident at the landscape scale. Recreational use was concentrated in the northern portion of the NCA, which is more accessible from the Boise Metropolitan Area where most recreationists live (Chapter 1). Different types of recreation were concentrated in distinct areas of the northern NCA (Chapter 1), which may have occurred because of different site needs or because certain types of use prevent other groups from using portions of the site. Managers mentioned that other user groups may be displaced from areas with high amounts of recreational shooting specifically (Chapter 2).

Recreational shooters stood out as a distinct social group when compared with birdwatchers, managers, and biologists (Chapter 2). They were more accepting of trash dumping but were more sensitive to crowding impacts than the other social groups (Chapter 2). As expected, birdwatchers' opinions were more closely aligned with professionals, likely because their activity is more reliant on natural resource conditions (Stemmer et al. 2022). Recreational shooters also showed potential for conflict with management agencies. They placed less responsibility on management agencies for enforcing rules and regulations than other potential enforcers and showed low support for management changes or limits to site use. Instead, recreational shooters placed high responsibility on individuals to follow rules and regulations and stay safe (Chapter 2). This could lead to conflict or a disregard for messages and actions from management agencies rather than groups that are respected by the recreational shooting community.

Impacts of Recreation on the Natural System

I examined the impact of recreational use on the natural system and feedbacks within the natural system using a spatially and temporally informed variable of recreation intensity. The abundance of Piute ground squirrels (*Urocitellus mollis*), a keystone prey species at the NCA, had a positive relationship with recreational shooting, likely due to shooters selecting sites with ground squirrels (Chapter 1), and was positively affected by native shrub cover (Chapter 3). Avian and mammalian scavengers, particularly common ravens (*Corvus corax*), were more abundant in areas with greater recreational use (Chapter 3), which is consistent with other studies showing that these species capitalize on supplemental food sources (White 2005, Lafferty et al. 2016, McTee et al. 2019). Horned larks (*Eremophila alpestris*), an abundant ground-nesting bird species at the NCA, had lower breeding densities in areas with more recreation, but their nesting success was not impacted by recreation (Chapter 3). Conversely, long-billed curlews (*Numenius americanus*), a less abundant ground-nesting bird and species of conservation concern in Idaho (Idaho Department of Fish and Game 2017), showed no relationship between recreation intensity and breeding density but had much lower nesting success in areas with higher recreation intensity (Chapter 3).

Over time, impacts to multiple species in the sagebrush-steppe ecosystem and the difference in the direction of impact could lead to changes in species interactions and indirect impacts to species. As a keystone prey species, Piute ground squirrels are important for the success of many species at the NCA (Steenhof et al. 2006). We did not find evidence of negative impacts to ground squirrel populations in areas with high recreational use. However, if environmental pressures, such as multiple drought years or

loss of important shrub habitat, are combined with recreational killing of Piute ground squirrels over multiple seasons or in limited habitat, there could be population-level impacts on this essential prey species. These impacts would have cascading negative impacts on predators within the system. Although avian and mammalian scavengers seem to be attracted to areas where recreational shooting provides supplemental food (Chapter 3), the carcasses left behind after shooting events most likely contain lead fragments, which could have negative effects on individuals and populations (Haig et al. 2014, Behmke et al. 2017, Herring et al. 2016, 2021, McTee et al. 2019). Further, benefits to foraging avian and mammalian scavengers may not translate to benefits to nesting raptors, which could experience disturbance and decreased reproductive success because of recreational disturbance (Spaul and Heath 2016) as well as increased competition and harassment from ravens (Craighead and Mindell 1981, Bauer and McDonald 2018). As a result, recreation may have a negative impact on population trends over time despite having positive effects on the short-term abundance of scavengers. Ground-nesting birds, particularly curlews, exhibit lower nesting success at the NCA than in other areas of their range that are without recreational pressure (Camfield et al. 2010, Coates et al. 2019). The attraction of scavengers to areas with high recreational use may also lead to increased predation on ground-nesting birds and their nests (Boarman 2003, Bui et al. 2010), exacerbating the stress of recreational disturbance and leading to further population declines of a species that is of conservation concern.

Impacts of the Natural System on Recreation

Recreational shooters consider environmental factors when selecting a site, particularly the availability of hills that can be used as backstops for shooting (Chapter

1). The availability of backstops may limit site choice if shooting use expands into the NCA or it may lead to an increase in unsafe shooting if safe spots are not available. Recreational shooters do not report being heavily influenced by other environmental factors, such as vegetation or wildlife, with the exception of ground squirrel hunters who check approximate ground squirrel abundance before shooting at a site (Chapter 1). Recreational shooters and other recreationists were affected by the weather and tended to increase use on warmer days but avoid the hottest temperatures (Chapter 1). As climatic conditions change, this relationship may result in more recreationists at the NCA during the spring and early summer when temperatures are in their preferred range (Wilkins et al. 2021).

In addition to direct effects of environmental and climatic variables on recreational use, the decisions of management agencies based on environmental conditions could change recreational use. Managers and biologists report high levels of concern for the impact of recreation on wildlife and habitat at the NCA (Chapter 2). This concern could result in the implementation of one or more of the suggested management changes, some of which would restrict recreational use (Chapter 2). Recreationists consider the NCA to be a unique and accessible site that provides opportunities that are not possible at shooting ranges or other organized recreation venues (Chapter 1). They may be unwilling to change sites if restrictions are put in place, which could lead to resistance or unwanted behaviors.

Telecoupling

Telecouplings, or linkages between the NCA and other Coupled Human and Natural systems, were also an important phenomenon in our system, particularly when

considering outside effects on the number of recreationists using the site. The urbanization and growth of the Boise Metropolitan Area has resulted in more potential recreational users in the area surrounding the NCA (U.S. Census Bureau 2020) and a larger human footprint on the landscape (Leu et al. 2008). During my study, the COVID-19 pandemic resulted in increased recreational use in the NCA (Chapter 1) and other recreation areas (Hockings et al. 2020, Geng et al. 2021, Landry et al. 2021, Rice and Pan 2021). In interviews, recreational shooters cited the price of gasoline and ammunition as deterrents to recreation (Chapter 1), although we did not assess this relationship. It is important to consider how these connections to distant systems affect the system of recreation on public lands.

Management Implications

One of the goals of this research was to provide insight into the management of the NCA and other public lands across the western United States that are experiencing similar challenges. I used the findings of each chapter, management actions suggested by interview participants, and the Rare Center for Behavior and the Environment's Levers of Behavior Change (Rare 2021) to compile impacts and suggested actions (Table C.1).

Table C.1. Recreation impacts at the Morley Nelson Snake River Birds of Prey National Conservation Area (NCA) in southwest Idaho and proposed actions to address impacts.

Impact	Suggested Action	Action rationale (Rare 2021)
Trash (Chapter 2)	Place more trash bins in high use locations at the NCA, including some located further north on the main access road	Accessible bins decreased the cost (time) of the desired behavior (removing trash after shooting).
	Use messaging to establish a social norm of picking up trash within the shooting recreation group	Messaging uses social influences to make the target behavior the norm within the social group. It also uses an emotional appeal, the prospect of shame for not following the social norm.
	Clean up trash at shooting sites, particularly in areas where shooting is discouraged (i.e., ecologically important areas)	Clean sites make the behavior of other recreationists (i.e., leaving the site clean) observable, so the descriptive social norm (behavior) matches the injunctive social norm (disapproval; Cialdini et al. 2006). This increases the efficacy of social norm messaging. Shooters avoid spots that are clean to avoid disturbing them (Chapter 2).
Illegal killing of protected wildlife (Katzner et al. 2020, Chapter 2)	Provide basic information about shooting (e.g., where to find full regulations, hunting license are required to shoot unprotected mammals) at sporting goods stores	This provides clear information about the target behavior at a source that most recreational shooters will encounter. As members of the social group, sporting goods store employees may be more effective messengers than management agencies.
	Provide basic information about shooting at stops along access roads to the NCA on high use days	Another way to provide clear information about the target behavior at a source that most recreational shooters will encounter. Members of the social group may be more effective messengers than management agencies.
	Increase law enforcement and management presence at the site	This increases the perceived cost of undesirable behaviors (illegal shooting) and helps to enforce the

		rules and regulations that prohibit the behavior.
	Increase awareness of consequences of illegal killing of protected wildlife	This strategy also increases the perceived cost of the undesirable behavior.
	Create a 1-km buffer around power lines and transmission lines where shooting is restricted	This would create a specific regulation in an area where birds are at high risk of being shot and where law enforcement can easily determine if someone is not following the rule.
Safety (Chapter 2)	Provide information about what makes an effective backstop (i.e., tall and wide enough to block all shots, appropriate distance from the shooting group, few rocks to prevent ricocheting bullets)	This provides clear information about how to perform the target behavior (using an effective backstop), which shooters report using as a top factor when selecting a shooting site (Chapter 1).
	Provide information about other uses of the site	Research and military training often require moving through the NCA off road, which is not a typical behavior for recreationists at the site. Shooters may not be aware of these user groups.
Crowding (Chapter 2)	Use indirect methods of directing recreational users, which could include: Improved roads and backstops in areas that should be used Increased perception of military presence in areas that are undesirable for use	These methods provide affordances to push recreationists to select sites in preferred areas without requiring enforcement or restrictions on use.
	Monitor recreational use in suitable sites that are not currently being used (Chapter 1)	As crowding levels reach unacceptable thresholds, more users may travel further into the NCA. Monitoring areas that may be suitable alternatives helps to prevent social or ecological conflicts.

Decreased breeding bird nesting success (Chapter 3)	Spatial or temporal closures in areas and time periods that are important for breeding success	This creates a rule that prohibits recreation to minimize ecological impacts.
	Use affordances (listed above) to indirectly keep use away from ecologically sensitive areas	These methods provide affordances to help recreationists select sites in preferred areas without requiring enforcement.
Lead uptake by scavengers (Chapter 2)	Spatial or temporal closures in areas and time periods that are important for raptors, especially for ground squirrel hunting, which leads to carcasses with lead fragments on the landscape for scavenging ravens (McTee et al. 2019, Herring et al. 2021)	This creates a rule that prohibits recreation to minimize ecological impacts.
	Require lead-free ammunition in areas or time periods that are ecologically important for raptors	This creates a rule to minimize ecological impacts without fully restricting recreation.
	Use social influence messaging to encourage a switch to lead-free ammunition on a broader scale	Shooters are resistant to changing their shooting habits and many perceive lead-free ammunition as less effective (Chapter 2). Social influences coupled with information about the impacts of lead may help to change the norm within the social group and reduce lead on the landscape.
Potential impacts to a keystone prey species	Monitor Piute ground squirrel populations, especially in heavily used areas	This would help to determine if prey populations are being impacted by recreational shooting, drought, or other factors over time.
	Require an NCA-specific tag for hunting unprotected mammals at the NCA	This tag could require Hunter Education courses to teach recreationists at the NCA about the unique raptors and natural resources at the site. It could also be used to place limits on the number of squirrels or other prey species killed if necessary.

These results help us begin to understand the dynamic Coupled Human and Natural System of recreation on public lands. The interactions between and within social and ecological systems at the NCA give us insight into the current system dynamics, as well as how the system may change in the future. Together, these insights provide information that can help to balance conservation with recreation opportunities and work to make the system sustainable and resilient into the future

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APPENDIX A: CHAPTER ONE SUPPLEMENTAL MATERIALS

On-site Sampling

We intercepted visitors along access roads from 13 March to 25 July 2021. We used a stratified random approach with two strata of days – weekdays and weekend/holidays – to select survey days. On selected days, we surveyed for 1 – 4 hours at a survey location along the NCA access roads (Table A.1).

Table A.1. On-site survey sampling blocks for surveys at the Morley Nelson Snake River Birds of Prey National Conservation Area from March to July 2021.

Block	Date (dd/mm/yyyy)	Location	Time Block	Start	End	Duration (min)	Surveys	Response Rate
1	14/03/2021	PV	4pm-8pm	1637	1907	150	12	100.0
2	17/03/2021	PV	4pm-8pm	1615	1945	210	1	14.3
3	21/03/2021	PV	4pm-8pm	1624	1934	190	2	33.3
4	24/03/2021	PV	12pm-4pm	1220	1430	130	0	0.0
5	24/03/2021	SF	4pm-8pm	1700	1900	120	0	0.0
6	28/03/2021	PV	12pm-4pm	1530	1600	30	2	100.0
7	28/03/2021	PV	4pm-8pm	1635	1735	60	0	0.0
8	30/03/2021	PV	12pm-4pm	1415	1630	135	0	0.0
9	07/04/2021	PV	12pm-4pm	1200	1400	120	1	25.0
10	18/04/2021	PV	12pm-4pm	1228	1415	107	1	33.3
11	03/05/2021	PV	12pm-4pm	1230	1400	90	0	0.0
12	09/05/2021	PV	12pm-4pm	1303	1433	90	0	0.0

13	11/05/2021	PV	12pm-4pm	1235	1535	180	1	20.0
14	14/05/2021	PV	12pm-4pm	1338	1600	142	1	16.7
15	16/05/2021	PV	12pm-4pm	1325	1500	95	0	0.0
16	30/05/2021	PV	12pm-4pm	1525	1600	35	0	0.0
17	30/05/2021	PV	4pm-8pm	1600	1745	105	0	0.0
18	31/05/2021	PV	12pm-4pm	1200	1400	120	0	0.0
19	05/06/2021	PV	4pm-8pm	1630	1800	90	1	33.3
20	11/06/2021	PV	4pm-8pm	1600	1700	60	0	0.0
21	12/06/2021	SF	4pm-8pm	1630	1830	120	0	0.0
22	13/06/2021	PV	12pm-4pm	1250	1450	120	2	66.7
23	14/06/2021	PV	12pm-4pm	1155	1325	90	1	33.3
24	19/06/2021	PV	12pm-4pm	1400	1500	60	0	0.0
25	20/06/2021	PV	12pm-4pm	1455	1625	90	1	20.0
26	06/06/2021	PV	12pm-4pm	1338	1600	142	0	0.0
27	11/06/2021	PV	12pm-4pm	1430	1600	90	0	0.0

28	26/06/2021	SF	12pm-4pm	1502	1602	60	0	0.0
29	02/07/2021	PV	8am-12pm	1100	1200	60	0	0.0
30	03/07/2021	PV	12pm-4pm	1400	1500	60	0	0.0
31	10/07/2021	PV	12pm-4pm	1425	1520	55	0	0.0
32	11/07/2021	PV	8am-12pm	910	1130	140	1	14.3
33	21/07/2021	PV	8am-12pm	830	1040	130	0	0.0
34	25/07/2021	PV	8am-12pm	955	1215	140	0	0.0

Summary of Additional Survey Questions

Recreationists were asked several questions that were not directly relevant to our research question but may provide useful additional detail (Table A.2). We asked recreationists about their general trip planning when recreating at the NCA. Recreationists were typically from the surrounding area and spent an hour or less driving to the site. They reported spending between 30 minutes and 7.5 hours recreating at the site (2.7 ± 1.4 hours). People who were hunting Piute ground squirrels (*Urocitellus mollis*) reported a wide range of squirrels shot during a single shooting day (0 to 200 squirrels) and ranged from opportunistic squirrel hunters to people who keep records of the number of squirrels they killed each day they go hunting.

We asked recreational shooters how often they participate in various activities related to shooting, such as indoor shooting ranges or public lands. In addition to the activities we asked about, participants also mentioned shooting for self-defense, testing homemade firearms, shooting clay pigeons, and participating in competitions at shoot ranges. We also asked participants to rank shooting at an indoor range, an outdoor range in town, an outdoor range out of town, private land, and public land. Public land was ranked the highest (1.4), followed by outdoor ranges out of town (3.0), private land (3.1), outdoor ranges in town (3.7), and indoor ranges (4.4). Recreational shooters described indoor shooting ranges as crowded, costly, loud, and boring. They also noted that indoor ranges are the most regulated, which restricts the types of shooting that are possible. Outdoor ranges were described as having costs and benefit. Public lands were preferred for a variety of reasons. Many shooters mentioned the lack of a fee as a benefit of using public lands. Others mentioned that they feel safer shooting in an area with less people

than a designated range. Public lands were also valued for their freedom and lack of regulation, which allows for a greater range of shooting activities and more self-paced shooting. Several participants mentioned their feeling of ownership in public lands and desire to use those spaces. One participant mentioned that the NCA was a more approachable place to gain shooting experience.

We asked recreationists to rate the importance of potential motivations from 1 (not at all important) to 5 (extremely important). Recreational shooters rated having fun (4.79 ± 0.62), practicing their skills (4.79 ± 0.74), and testing their skills (4.72 ± 0.60) as the most important motivators, while other recreationists rated enjoying nature (4.88 ± 0.45) and having fun (4.71 ± 0.46) as top motivators.

Table A.2. Summary of relevant survey questions asked of recreationists in southwestern Idaho through an on-site survey at the Morley Nelson Snake River Birds of Prey National Conservation Area and online from April 2020 to July 2021. Summary statistics are based on the number of individuals who responded to each question. One non-shooting recreationist took the on-site survey and is included in the overall sample.

Question	Overall (n = 103)	Shooting On-site (n = 23)	Shooting Online (n = 19)	Other Rec Online (n = 60)
		Trip Information		
Minutes driving to the site	32.8 ± 18.1	37.6 ± 14.6	38.5 ± 15.2	29.7 ± 19.5
Minimum	7.5	15	7.5	7.5
Maximum	60	60	60	60
Time recreating (hr)	2.7 ± 1.4	3.4 ± 1.8	2.8 ± 1.0	2.5 ± 1.3
Minimum	0.5	1.0	1.5	0.5
Maximum	7.5	7.5	4.5	4.5
Ground squirrels shot	34.6 ± 57.1	86.3 ± 74.3	23.7 ± 48.4	
Minimum	0	2.5	0	
Maximum	200	180	200	
Comments about shooting ground squirrels	[1] *As much as I can hit.* [2] *12 per hour, up to 20 to 70 per hour.* [3] *I'll shoot them if I see them.* [4] *Only opportunistically.* [5] *2 to 3 on average, it's opportunistic*. [6] *25 to 100.*			
		Venue and Activity Frequency		
Indoor range frequency:				
Never	58 (21)	67 (14)	47 (7)	
Every 2+ years	11 (4)	0 (0)	27 (4)	
Once or twice a year	22 (8)	28 (6)	13 (2)	
Once or twice a month	3 (1)	5 (1)	13 (2)	
Once or twice a week	6 (2)	0 (0)	0 (0)	
Nearly every day	0 (0)	0 (0)	0 (0)	

Outdoor recreation facility:				
Never	59 (58)	50 (11)	19 (3)	73 (44)
Every 2+ years	8 (8)	5 (1)	6 (1)	10 (6)
Once or twice a year	16 (15)	18 (4)	19 (3)	13 (8)
Once or twice a month	11 (11)	18 (4)	31 (5)	3 (2)
Once or twice a week	4 (4)	5 (1)	19 (3)	0 (0)
Nearly every day	2 (2)	5 (1)	6 (1)	0 (0)
Recreating on public land frequency:				
Never	46 (46)	0 (0)	13 (2)	73 (44)
Every 2+ years	8 (8)	0 (0)	6 (1)	13 (7)
Once or twice a year	13 (13)	13 (3)	31 (5)	8 (5)
Once or twice a month	19 (19)	39 (9)	38 (6)	7 (4)
Once or twice a week	13 (13)	48 (11)	13 (2)	0 (0)
Nearly every day	0 (0)	0 (0)	0 (0)	0 (0)
Ground squirrel shooting frequency:				
Never	71 (69)	48 (10)	19 (3)	93 (53)
Every 2+ years	3 (3)	5 (1)	13 (2)	0 (0)
Once or twice a year	12 (12)	10 (2)	38 (6)	7 (4)
Once or twice a month	5 (5)	19 (4)	6 (1)	0 (0)
Once or twice a week	7 (7)	14 (3)	25 (4)	0 (0)
Nearly every day	1 (1)	5 (1)	0 (0)	0 (0)
Sighting in rifle frequency:				
Never	32 (12)	45 (10)	13 (2)	
Every 2+ years	5 (2)	0 (0)	13 (2)	
Once or twice a year	39 (15)	32 (7)	50 (8)	
	16 (6)	18 (4)	13 (2)	
	8 (3)	5 (1)	13 (2)	

Once or twice a month	0 (0)	0 (0)	0 (0)
Once or twice a week			
Nearly every day			
Hunting practice frequency:			
Never	32 (12)	50 (11)	6 (1)
Every 2+ years	8 (3)	0 (0)	19 (3)
Once or twice a year	32 (12)	32 (7)	31 (5)
Once or twice a month	21 (8)	14 (3)	31 (5)
Once or twice a week	8 (3)	5 (1)	13 (2)
Nearly every day	0 (0)	0 (0)	0 (0)
Other shooting activities:	*Necessary, self-defense, test firing homemade firearms, shooting clay pigeons, competitions at shooting ranges, monthly competitions*		
Other non-shooting activities:	*ATV, camping, cycling (road and mtn biking), enjoying nature, falconry, golf, horse riding, nature journaling, photography, rock hounding, running, scenic driving, walking*		
Ranking venues:			
Indoor Range	4.4	4.4	4.4
Outdoor Range (in town)	3.7	3.9	3.3
Outdoor Range (out of town)	3.0	3.0	-
Private Land	3.1	3.3	2.7
Public Land	1.4	1.3	1.5
Venue comments	Indoor ranges: [1] *Crowds, cost.* [2] *Most regulated*. [3] *Too loud, boring*. Outdoor ranges: [4] *Known range is a plus but it's more regulated*. [5] *Wish there was something like* [the George Norse Range in Nampa, Idaho] – *nice, safe, not crowded.* [6] *No interest, I don't want to be surrounded by other people*.		

	Private land: [7] *Best.* [8] *Can find Airbnbs in the mountains where you can shoot*. [9] *Only for hunting*. Public land: [10] *Free, unregulated*. [11] *The only place I shoot.*
Why do you prefer shooting on public lands?	[1] *I like being outside. You don't have to worry about other people or rules, no close to others which feels safer, there's no cost*. [2] *No payment, you can't rapid fire indoors, not safe around strangers, indoor ranges are loud and limit what kinds of guns you can shoot*. [3] *No payment*. [4] *No payment, I'm an owner of public land, so I want to use it*. [5] *Safety is my number one priority. Fewer people* [on public lands relative to at an indoor range*], fewer accidents*. [6] *Indoor ranges cost money to use.* [7] *Safe, close, time efficient*. [8] *More space and options*. [9] *Less traffic, away from people, more range, no cost, can do other activities* [hiking, 4-wheeling] *while out here*. [10] *Most freedom and space, cost effective*. [11] *Taxpayers pay for public land but also have a responsibility to take care of it. I don't mind other people but prefer solitude.* [12] *Gives you a chance to enjoy nature.* [13] *You can get away from other people. At ranges it can be dangerous because you're around people you don't know or trust.* [14] *Less crowded, not as busy, enjoy getting outside, being in solitude. Indoor is noisy even with ear protection.* [15] *Prefer not to be around people, ranges are too loud. Being out in the open is better.* [16] *Ranges have too many people and are a controlled environment. I don't want to shoot with other types of shooters – for example, hunters because I don't agree with trophy hunting.* [17] *The others are expensive*. [18] *The scenery, the view. It's a 15 – 20 minute drive and you can see the Owyhee and foothills*. [19] *For now I'm gaining experience out here* [the NCA]. *I will maybe go to ranges in a few months because they're more challenging. The NCA is a more approachable place to get familiar with guns. Ranges are expensive, and if you're not using them how you're supposed to, you're preventing others from shooting.* [20] *I like access to public lands and solitude.* [21] *Don't have to be around other people. I can walk back and forth to the target whenever I want. I can set my own range. It's very independent.* [22] *I like being outside and away from people.*

Motivation				
Enjoying Nature				
Not at all important	0 (0)	0 (0)	0 (0)	0 (0)
Slightly important	3 (3)	9 (2)	0 (0)	3 (2)
Moderately important	5 (5)	13 (3)	13 (2)	0 (0)

Important	8 (8)	18 (4)	0 (0)	7 (4)
Extremely important	84 (81)	59 (13)	87 (13)	90 (54)
Comments about enjoying nature	[1] *I like getting out of town. The desert is pretty in its own way, but I'm from northern Idaho and there's more to look at there.* [2] *Fun to be out*. [3] *Getting away*. [4] *I like seeing the mountains, something that's not a city*. [5] *Nature is why out at the NCA is better than indoors or at a range*. [6] *I like just being out*.			
Experiencing solitude				
Not at all important	1 (5)	14 (3)	7 (1)	2 (1)
Slightly important	10 (9)	9 (2)	0 (0)	11 (6)
Moderately important	11 (10)	14 (3)	47 (7)	0 (0)
Important	26 (24)	14 (3)	0 (0)	40 (21)
Extremely important	47 (43)	50 (11)	47 (7)	47 (25)
Comments about experiencing solitude	[1] *I'm always near people when out here* [at the NCA]. [2] *I deal with people at my job, I don't want to out here.* [3] [Solitude is the] *biggest reason*. [4] *I work with the public for 6 days. Everyone is crazy. So I need solitude.* [5] *Sometimes – I run three businesses, so it's nice to have solitude.* [6] *Pre-COVID this would have been extremely important, but it's now only important.* [7] *I don't think about this, but it's an important aspect.* [8] *I'm usually with my son and his friend.*			
Spending time with friends or family				
Not at all important	4 (3)	0 (0)	0 (0)	7 (3)
Slightly important	8 (7)	14 (3)	0 (0)	9 (4)
Moderately important	10 (8)	18 (4)	27 (4)	0 (0)
Important	21 (18)	14 (3)	0 (0)	33 (15)
Extremely important	57 (48)	55 (12)	73 (11)	52 (24)
Comments about spending time with friends or family	[1] *This is mostly the reason.* [2] *I have a couple friends I go with, but it's usually an impulsive decision.* [3] *I generally come alone.* [4] *As long as I'm with people who aren't stupid.* [5] *Sometimes. I like to bring my family and friends, but they don't always want to go*. [6] *I go with my son and usually our neighbor*.			

Testing your skills				
Not at all important	16 (14)	0 (0)	0 (0)	32 (14)
Slightly important	7 (6)	0 (0)	0 (0)	14 (6)
Moderately important	4 (3)	13 (1)	13 (2)	0 (0)
Important	24 (20)	22 (5)	0 (0)	34 (15)
Extremely important	47 (40)	74 (17)	87 (13)	20 (9)
Comments about testing skills	No comments.			
Challenging yourself				
Not at all important	6 (5)	0 (0)	0 (0)	12 (5)
Slightly important	10 (8)	5 (1)	0 (0)	17 (7)
Moderately important	9 (7)	14 (3)	27 (4)	0 (0)
Important	29 (23)	27 (6)	0 (0)	39 (16)
Extremely important	46 (36)	55 (12)	73 (11)	32 (13)
Comments about challenging yourself	[1] *Want to know I can hit anything.* [2] *Mostly want to have a good day.*			
Getting exercising				
Not at all important	13 (12)	39 (9)	13 (2)	2 (1)
Slightly important	9 (8)	17 (4)	0 (0)	8 (4)
Moderately important	9 (8)	4 (1)	47 (7)	0 (0)
Important	26 (24)	26 (6)	0 (0)	34 (8)
Extremely important	43 (40)	13 (3)	40 (6)	57 (30)
Comments about getting exercise	[1] *I just go to the gym for exercise.* [2] *Only walk about 100 m while shooting.* [3] *Not* [a motivator] *when I'm shooting.*			
Viewing wildlife				
Not at all important	6 (6)	17 (4)	13 (2)	0 (0)
Slightly important	12 (11)	26 (6)	0 (0)	9 (5)
Moderately important	9 (8)	13 (3)	27 (4)	0 (0)
Important	21 (20)	13 (3)	0 (0)	31 (17)
Extremely important	52 (49)	30 (7)	60 (9)	60 (33)

Comments about viewing wildlife	[1] *Nice if it happens, but it's not a primary motivation. We see deer and coyotes, but probably not around shooting.* [2] *Like seeing new animals.* [3] *A bonus if it happens but not a motivator. The birds are cool.* [4] *There are pretty cool birds, the carrion birds specifically. I don't know the species*. [5] *I bring a camera with to take pictures of the antelope and birds.* [6] *I don't see a lot of wildlife, but I do see antelope, badgers, and coyotes.* [7] *I saw a baby badger today.*			
Having fun				
Not at all important	0 (0)	0 (0)	0 (0)	0 (0)
Slightly important	1 (1)	4 (1)	0 (0)	0 (0)
Moderately important	1 (1)	0 (0)	7 (1)	0 (0)
Important	21 (20)	13 (3)	0 (0)	29 (17)
Extremely important	77 (75)	83 (19)	93 (14)	71 (41)
Comments about having fun	[1] *Why do it if it's not fun?* [2] [The importance is] *off the chart*. [3] *Wouldn't be out here in the wind, sun, and bugs otherwise.*			
Practicing your skills				
Not at all important	9 (7)	4 (1)	0 (0)	14 (6)
Slightly important	11 (9)	0 (0)	0 (0)	21 (9)
Moderately important	1 (1)	4 (1)	0 (0)	0 (0)
Important	21 (17)	9 (2)	0 (0)	36 (15)
Extremely important	58 (47)	83 (19)	100 (15)	29 (12)
Comments about practicing skills	[1] *At least this important*. [2] *Have to be able to defend myself* [jokingly].			
Other reasons	[1] *To use God-given right and other rights*. [2] *Preparing for self-defense*. [3] *Testing homemade firearm functionality*. [4] *Relaxing, stress relieving, being outside in the sun.* [5] *I've been shooting all my life. It's part of my identity and a cultural thing from growing up in northern Idaho*. [6] *Shooting is a fun way to spend a spring day. Although I wish more people would pick up their trash and shooting debris*. [7] *Get out by myself in the quiet, clean air to take time and catch my breath. I'm overloaded with information most of the time, so I get out of cell service to regroup*. [8] *It's a hobby*. [9] *I work at a horse ranch. I like animals, not people. I get an air bath when I come out here.* [10] *To keep sharp.* [11] *Today is for doing drills for competitive shooting. I'm trying to get back into competing. I shoot*			

	competitively in the winter, then start again in the spring/summer. Other reasons are having fun and testing skills. [12] *Testing equipment, loads and guns*. [13] *Photography*. [14] *Relaxing*. [15] *Botanizing* [identifying/collecting plants]. [16] *Horse riding.* [17] *The view.* [18] *Access to game*. [19] *Spending time with my son and getting to know the areas around. I grew up in Nampa* [Idaho] *and went to Pickel, but I hadn't been out here* [the NCA]. *I'm trying not to ruin the activity* [OHV riding] *for my son*.

Additional Figures

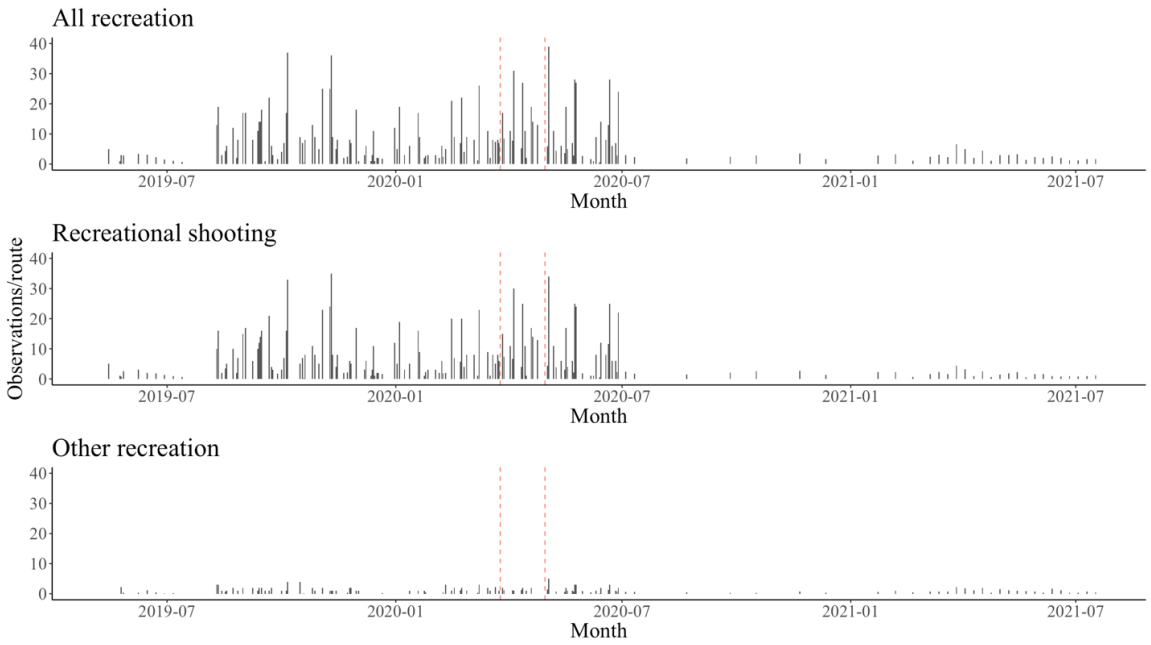


Figure A.1. The number of observations per route for driving surveys from 15 May 2019 to 17 July 2021 at the Morley Nelson Snake River Birds of Prey National Conservation Area in southwestern Idaho. Dashed lines mark the start (25 March 2020) and end (30 April 2020) of the Stay Home order in Idaho.

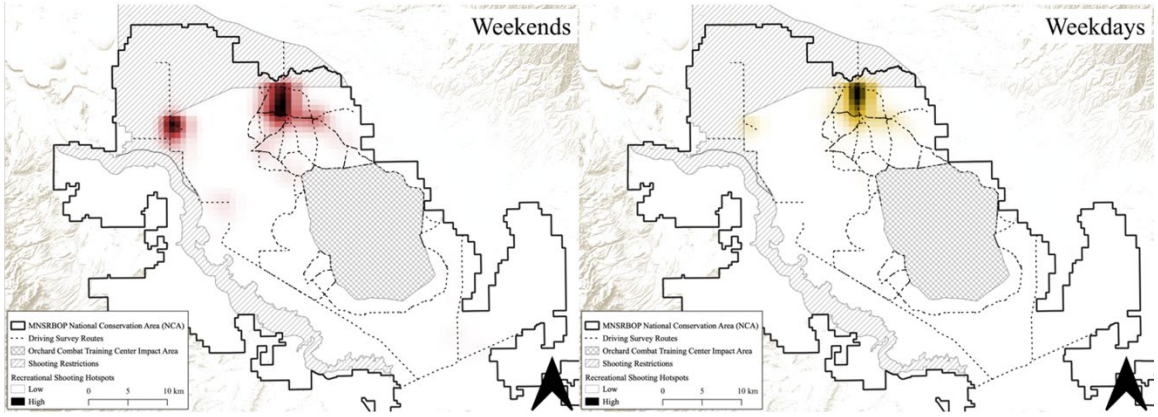


Figure A.2. Shooting hotspots on weekends (A) and weekdays (B) at the Morley Nelson Snake River Birds of Prey National Conservation Area in southwest Idaho

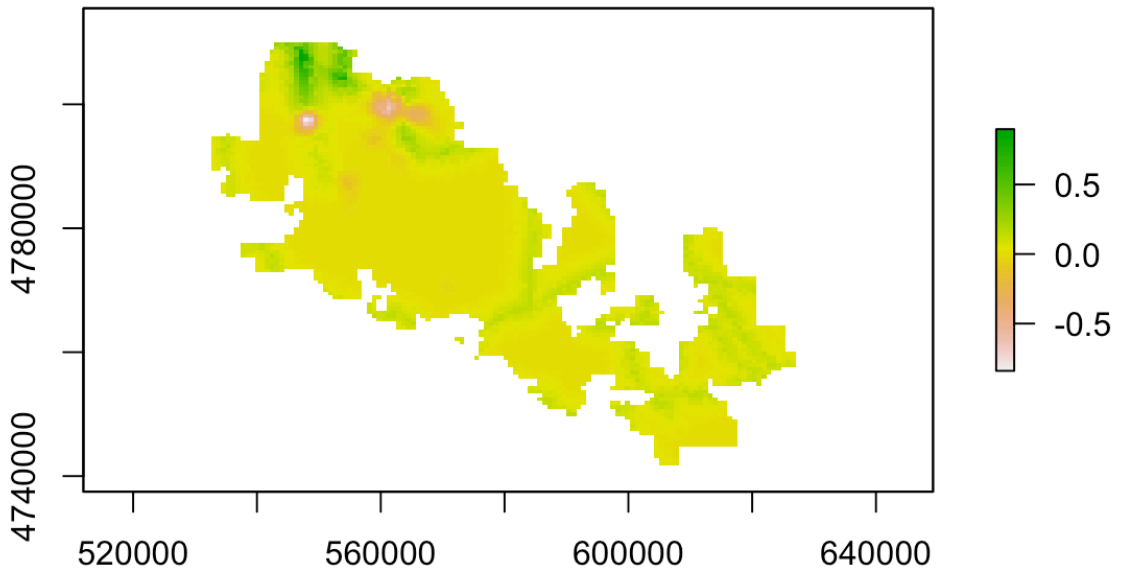


Figure A.3. Differences in spatial patterns for expected and observed recreational where expected values come from a habitat suitability map (Pauli et al. 2019). Observed values only included observations from February and March, which is the timeframe during which Pauli et al. (2019) sampled. Higher values (dark green) are areas with expected recreational shooting hotspots that were not observed, areas where predicted values match observed are close to zero (yellow/orange), and lower values are observed hotspots in areas that were not predicted (red/white).

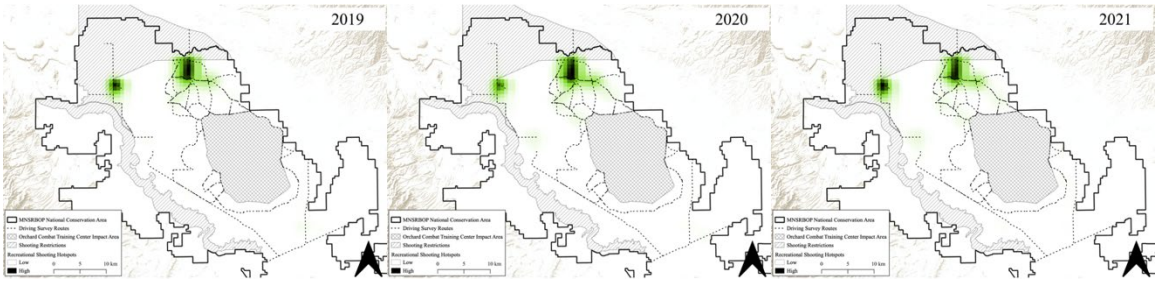


Figure A.4. Spatial patterns of recreational shooting use at the Morley Nelson Snake River Birds of Prey National Conservation Area in southwest Idaho in 2019, 2020, and 2021.

Manager Perspectives of Site Use

Trends in Recreation

In our interviews with managers and biologists at the NCA (see Chapter 2 for full details), we asked individuals who have regularly worked at the NCA for more than one year about changes in recreational use during their time at the site. They overwhelmingly reported an increase in use (83%). This included both an increase in the number of recreationists and in the spread of recreation throughout the site (25%). Professionals also mentioned changes in the type of use (25%), user behaviors (8%), and demographics (8%). One manager summarized these changes and potential drivers, [paraphrased] *Use has definitely changed over my time at the NCA. When I started, there weren't many people, and ground squirrel shooters were mostly out on Saturday and Sunday. There has been more of an increase in general target shooting than ground squirrel shooting. In particular, I noticed a big uptick in target shooting after Obama was elected in 2008. This included a change in the demographics of people shooting. They were younger – high school or college aged – men and women, and couples. That was the biggest uptick and use hasn't let up since.* Another described the spatial spread of use that has accompanied increases, [paraphrased] *Even in less than a decade I've seen a change. There's been an increase in the density and spatial extent of use. The area where people*

are willing to go has increased, and use is spreading to new locations – farther South and more on the East side. People have recently discovered access through Grand View Highway and Big Baja Road. I've also had more close calls in the field, even with spending less time out in the field, which suggests a change in behaviors as well.

Population increases in the surrounding metropolitan area and the COVID-19 pandemic were mentioned by several professionals as drivers of the increase in recreational use, [paraphrased] *There's been a huge increase with population in the valley and an increase in people shooting. During COVID, I saw an uptick in use, which I think is because people have more time and see being outside as a safe activity.*

Perceptions of Recreation Motivation

We also asked managers who interact with recreationists more frequently ($n = 7$) about their perceptions of recreation motivators (Figure A1.5). Managers perceived having fun as the most important motivator (4.50 ± 0.50) followed by enjoying nature (3.71 ± 1.41) and socializing (3.50 ± 0.50).

Managers thought that enjoying nature was [paraphrased] *In a more general sense – being outside.* Managers also commented on differences in how recreationists enjoy nature and behaviors that benefit nature, [paraphrased] *This is subjective. Technically shooting ground squirrels, or even illegally killing species, could be considered enjoying nature. They're enjoying nature but in ways I don't respect.*

Managers had mixed views on the importance of experiencing solitude for recreationists. One manager mentioned the unique ability to find solitude at the NCA *[paraphrased] There's this juxtaposition of being big and empty next to a metropolitan area. For some people it's the middle of nowhere.* Another called the NCA

[paraphrased] the closest middle of nowhere. Another manager doubted the availability of solitude at the NCA, [paraphrased] *Not at the NCA – it's so crowded.* Several managers mentioned the practical necessity of avoiding crowds while shooting or trying to avoid restrictions, which are not the same a seeking solitude, [paraphrased] *They want to get away from people/crowds, but not to be alone and experience solitude because often they're still with a group of people. I think they want to be far enough out so that their activities aren't restricted.*

Socializing with friends and family was viewed as an important motivator, [paraphrased] *Most people are out there with someone else. I sometimes see big family groups. Many people find out about the NCA from friends or family. People look at you suspiciously when you're alone.*

Managers tended to view practicing skills as less important than recreational shooters reported. One noted the difference between shooting at the NCA and hunting in other areas [paraphrased] *Target shooting and hunting non-game recreationists aren't taking it as seriously though. It's a lot less serious than other areas, like the Frank Church River of No Return Wilderness.* Others mentioned additional ways that recreationists test or challenge their skills, such as identifying plants or wildlife or seeking physical challenges. One mentioned [paraphrased] *Some challenge themselves by trying to get to places where they shouldn't be able to drive.*

Managers listed additional motivators for recreation at the NCA. Several focused on the accessibility of the site and the lack of similar areas, [paraphrased] *The NCA is the only area they can go. There is a lack of alternative areas for the activity* [target shooting, plinking ground squirrels]. *The NCA is public land, far from residential areas,*

and open to shooting. As far as illegal uses, like trash dumping, it's a free place to dispose of their trash versus going to the dump where they have to pay. Others focused on the freedom available to recreationists at the NCA, [paraphrased] *To be able to do whatever they want, to have no restrictions on their actions. Not necessarily because they are trying to behave badly, more for the freedom.*

One manager noted the strong value that Idahoans place on public lands, [paraphrased] *Recreationists value using their public lands. In Idaho especially people have a good understanding that public lands are paid for with their tax dollars. They want to use those lands and feel ownership. The awareness of public lands is very high here, but not necessarily the value of public lands, although that's subjective and my perspective.*

APPENDIX B: CHAPTER TWO SUPPLEMENTAL MATERIALS

On-site Survey Sampling

We used a stratified random sampling approach to select 4-hour time blocks at two locations within the NCA, then surveyed for 1 – 4 hours during the selected time block (Table A.3).

Table A.3. On-site survey sampling blocks for survey efforts at the Morley Nelson Snake River Birds of Prey National Conservation Area in southwest Idaho.

Block	Date	Location	Time Block	Start	End	Duration	Surveys	Response Rate
1	14/03/2021	PV	4pm-8pm	1637	1907	150	12	100.0
2	17/03/2021	PV	4pm-8pm	1615	1945	210	1	14.3
3	21/03/2021	PV	4pm-8pm	1624	1934	190	2	33.3
4	24/03/2021	PV	12pm-4pm	1220	1430	130	0	0.0
5	24/03/2021	SF	4pm-8pm	1700	1900	120	0	0.0
6	28/03/2021	PV	12pm-4pm	1530	1600	30	2	100.0
7	28/03/2021	PV	4pm-8pm	1635	1735	60	0	0.0
8	30/03/2021	PV	12pm-4pm	1415	1630	135	0	0.0
9	07/04/2021	PV	12pm-4pm	1200	1400	120	1	25.0
10	18/04/2021	PV	12pm-4pm	1228	1415	107	1	33.3
11	03/05/2021	PV	12pm-4pm	1230	1400	90	0	0.0
12	09/05/2021	PV	12pm-4pm	1303	1433	90	0	0.0

13	11/05/2021	PV	12pm-4pm	1235	1535	180	1	20.0
14	14/05/2021	PV	12pm-4pm	1338	1600	142	1	16.7
15	16/05/2021	PV	12pm-4pm	1325	1500	95	0	0.0
16	30/05/2021	PV	12pm-4pm	1525	1600	35	0	0.0
17	30/05/2021	PV	4pm-8pm	1600	1745	105	0	0.0
18	31/05/2021	PV	12pm-4pm	1200	1400	120	0	0.0
19	05/06/2021	PV	4pm-8pm	1630	1800	90	1	33.3
20	11/06/2021	PV	4pm-8pm	1600	1700	60	0	0.0
21	12/06/2021	SF	4pm-8pm	1630	1830	120	0	0.0
22	13/06/2021	PV	12pm-4pm	1250	1450	120	2	66.7
23	14/06/2021	PV	12pm-4pm	1155	1325	90	1	33.3
24	19/06/2021	PV	12pm-4pm	1400	1500	60	0	0.0
25	20/06/2021	PV	12pm-4pm	1455	1625	90	1	20.0
26	06/06/2021	PV	12pm-4pm	1338	1600	142	0	0.0
27	11/06/2021	PV	12pm-4pm	1430	1600	90	0	0.0

28	26/06/2021	SF	12pm-4pm	1502	1602	60	0	0.0
29	02/07/2021	PV	8am-12pm	1100	1200	60	0	0.0
30	03/07/2021	PV	12pm-4pm	1400	1500	60	0	0.0
31	10/07/2021	PV	12pm-4pm	1425	1520	55	0	0.0
32	11/07/2021	PV	8am-12pm	910	1130	140	1	14.3
33	21/07/2021	PV	8am-12pm	830	1040	130	0	0.0
34	25/07/2021	PV	8am-12pm	955	1215	140	0	0.0

Open-ended Response Code Book

We created a code book for open-ended interview responses in on-site surveys or interviews (Table A.4).

Table A.4. Code book used for open-ended questions.

Question	Category	Definition	Key Phrases	Exemplary Quote
stop.visit (rec)	safety	concern for their own safety, getting shot	unsafe, get shot, dangerous	Inappropriate gun use by uneducated groups who are not responsible. He doesn't want to get shot and will leave if he feels uneasy.
stop.visit (rec)	trash	concern about trash at shooting sites	trash, junk, debris, waste	Trash is off-putting.
stop.visit (rec)	crowds	concern about too many people using the site or not being able to find a spot to shoot	too many people, crowd, overuse	Consistent crowding.
stop.visit (rec)	fee	concern about a fee being required to use the site	fee	Fee for shooting access.
stop.visit (rec)	closures	concern about the site being closed to shooting	shut down, closure, banned	Fears that if people aren't accountable, BLM will shut down the area.
stop.visit (rec)	restrictions	concern about the areas where shooting is allowed being restricted	restrictions	Restrictions on shooting.

get.info / best.info	IDFG	Get information from the Idaho Departement of Fish and Game	IDFG, Idaho Dept of Fish & Game	I'm optimistic that a fair amount of people look at IDFG regulation.
get.info / best.info	other agency	Get info from an agency other than IDFG	BLM, IDARNG	
get.info / best.info	friends/family	Get info from social groups	social, friends, family, clubs, social groups	The majority get info from their friends. The first time people go out, many go with friends who have been there before, then they assume that what their friend is doing is legal and acceptable. They don't question what the person is doing or do their own research on the rules and regulations of the NCA or the activity // Everyone should be taking Hunter Education, but the social learning is important too. When you have groups of recreationists that grew up in small, tight-knit communities, their ideals come

				from their social groups.
get.info / best.info	other internet	Get info online, site not specified	online, internet	Most get info from the internet, but they typically research where they can shoot, not the rules and regulations.
get.info / best.info	none	People are not looking for info before going to the NCA	none, not looking, don't	They don't do their own research on the rules and regulations of the NCA or activity.
get.info / best.info	hunter education	Get info from Hunter Education courses	hunter education, hunting license	The more responsible users get their information from Hunter Education.
get.info / best.info	signs/kiosks	Get information from signs or kiosks on site	sign, kiosk	Also putting kiosks at the entrance, although people would probably shoot them.
get.info / best.info	stores	Get information at stores	store, sporting goods	Gun stores would be a good place to start.

rec.concerns (manage)	safety	concern for the safety of other recreationists, military, or researchers at the NCA. This is a broad category that includes the sub categories safety.public, safety.military, and safety.research	safety, danger	There are a lot of folks who don't think they're doing anything wrong. They don't think about how far bullets travel or the consequences of a stray bullet. People are "blissfully unaware, not purposeful" in general
rec.concerns (manage)	safety.public	concerns for safety - specified of other users at the NCA	safety, danger, other recreationists	The number of individuals shooting puts the public […] in danger
rec.concerns (manage)	safey.military	Concerns for safety - specified of military personnel	safety, danger, military, training	Military has a couple dozen incidents [with recreationists] every year. They do land navigation in very high recreation areas, wearing camouflage, navigating through the sage brush.
rec.concerns (manage)	safety.research	Concerns for safety - specifically while doing fieldwork/research at the NCA	safety, danger, research, I, me, field work	The last couple of years I've realized how far a bullet goes. When working in these areas, you have to be really aware of where people are shooting and how far bullets travel.

rec.concerns (manage)	habitat	Concern for habitat impacts of recreation, including degradation, new roads, invasive species	habitat, vegetation, shrubs, cheatgrass, degradation, road creation	Habitat impacts. For example, shrub sites that experience a lot of shooting can become bare ground when the shrubs get shot up.
rec.concerns (manage)	wildlife	Concern for wildlife impacts, which can be direct or indirect *included anyone who mentioned illegal shooting or lead*	wildlife, raptors, snakes, direct/indirect, disturb, displace, illegal killing,	Impacts to wildlife populations.
rec.concerns (manage)	illegal killing	Concern about the illegal killing of protected wildlife species	shot birds, wildlife, killing, protected species	It only takes 5-10 seconds of thoughtlessness to shoot a protected species and there's direct evidence this happens.
rec.concerns (manage)	lead	Concern for lead uptake in scavengers	lead, lead uptake, shot fragments	Shooting leaves .22 shot fragements in prey, a scavenger eats the carcasee, uptakes lead.
rec.concerns (manage)	fire	Concern for increased fire as a result of recreation	fire, exploding targets	Driving over cheatgrass or using exploding targets has a high fire risk and all of the human-caused fires outside of the impact area have been started by members of the public.

rec.concerns (manage)	trash	Concern for people leaving trash behind at recreation sites	trash, junk, debris, waste	Trigger trash degrading and decreasing available habitat
rec.concerns (manage)	cultural resources	Concerns about impacts to cultural artifacts at the site	artifacts, cultural	Impacts to cultural resources - people driving through the site and taking artifacts.
rec.concerns (manage)	property damage	Concern for damage to property at the site	damage, power structures, field equipment	Shooting power structures, which leads to a lot of damage. Had 30 shots in a single span of line, people shoot steel lattice structures, put up targets on power poles.
rec.concerns (manage)	recreation experience	Concerns for how the actions of some recreationists impact others	other people, experience, expectations	People not getting what they expect from the NCA.
rec.concerns (manage)	bad behavior	Concerns about bad behavior from recreationists.	behavior, signs get shot, driving off road, not following rules	Open access is not working. No amount of patrolling is going to stop some people. And there is no enforcement of restricted areas and signs get shot […] At what point do we add restrictions?

rec.concerns (manage)	difficulty of regulating	Concerns about the difficulty of regulating shooting at the site	regulate, lack of resources, manage, lack of personnel	Shooting is hard to regulate and doesn't seem like a type of recreation to have in an area of conservation concern. It's hard to actually manage and would need a lot of management to reduce illegal shooting.
rec.concerns (manage)	overuse	Concerns about the amount of use at the site	overuse, number of people, too many	It's a backyard play area. There's evidence that use is unsustainable, then add population growth and illegal shooting on top of that.
rec.concerns (manage)	lack of data	Concern about a lack of data/understanding of the problem	data, understanding, lack	Biggest concern right now is the lack of understanding of the scope of recreation [spatial and temporal extent ecological impacts] and trend data. We need a grasp on what's going on before we can address it through public understanding - without an understanding, we have no narratives to use in educational efforts.

rec.conflict (manage)	indirect - user groups	Conflict by general annoyance between user groups	annoyance, not appreciate, groups	I could see how birdwatchers might not appreciate hunters - definitely some personal issues [annoyance with other groups], but I don't know of any physical confrontations
rec.conflict (manage)	indirect - displace	Indirect conflict where one type of use makes an area unusable for other recreationists	avoid, go further, self-separate	There's so much land that people can just leave and find a new spot. There are other options. People also know to avoid areas with lots of shooting
rec.conflict (manage)	safety - usersafety	Conflicts with the safety of other users	other recreationists, safety	
rec.conflict (manage)	safety - research	conflicts with the safety of researchers		While doing research has had some close calls with people not using a proper backstop only 50 m away
rec.conflict (manage)	safety-military	Conflicts with military use	military, training	Military has a couple dozen incidents [with recreationists] every year. They do land navigation in very high recreation areas, wearing camouflage, navigating

				through the sage brush.
rec.conflict (manage)	livestock	Conflict with livestock grazing in the NCA	livestock, cattle, grazing, ranchers	There has been an increase in livestock shot, people aiming at bulls, and the way they shoot them [bulls] causes them to die slowly or have to be euthanized. Ranchers are starting to refuse to bring out their bulls.
rec.conflict (manage)	crowds	Conflict through overcrowding	crowds	People are piling up, squished.
rec.conflict (manage)	none	No conflict between recreationists	none, not conflict	Not really any conflicts between recreationists. Everyone out there is kind of on the same page. Target and ground squirrel shooters and ohv users have a lot of overlap in participants. Other activities don't really overlap, either spatially or through the use of resources. All of the activities in this area have about the same level of destructiveness.

rules.legal (manage)	know	People know what is legal to shoot	know rules and regulations, responsible, follow	There are responsible shooters who know the rules and regulations
rules.legal (manage)	don't know	People don't know what is legal to shoot	don't know	People who shoot and don't know what they're after. This could be because they're new to the area and/or the sport.
rules.legal (manage)	mix	There are a mix of people who know the regulations and do not at the NCA	also, mix,	There are absolutely people who shoot illegally and do so knowingly, but there are also many folks who don't hunt and don't know what's legal to shoot.
rules.legal (manage)	purposefully shooting illegally	People who know they are illegally killing protected species	knowingly, illegal, know and don't care	Think that most people know but don't care and aren't concerned with getting caught.
rules.legal (manage)	snakes	Concern for snakes and other herp	snakes, herp	A lot of people are surprised to learn they can't shoot snakes.
rules.legal (manage)	mammals	concern for mammals	mammal, ground squirrel, small mammals	Has concerns about "anything over the size of a ground squirrel" - large raptors, ravens, **mammals (coyotes, badgers)**, rattlesnakes.

rules.legal (manage)	birds	Concern for birds - generally and including any of the subcategories (raptors, curlews, ravens, sparrows)	birds	Yes. Is most concerned about snakes, **raptors, birds**, and non-target mammals
rules.legal (manage)	raptors	Concern for raptors and eagles	eagles, raptors,	Worried about raptors and eagles in particular being shot illegally and about people being aware of the rules surrounding them.
rules.legal (manage)	curlews	Concern for curlews	curlews	Also concerned with long-billed curlews because they are out in these areas but not always noticed by people. The general public isn't aware of what a curlew is.
rules.legal (manage)	raven	Concern for ravens	raven	Has concerns about raptors, curlews, and **ravens**.
rules.legal (manage)	sparrow	Concern for sparrows	sparrow	Some species are unknown - ravens, sparrows, small things.
rules.legal (manage)	hunter education (HE)	Concern that people don't realize they need a hunting license and to attend hunter education to shoot ground squirrels	hunter education, hunting license	Most people don't even know that you need Hunter Education.

rules.legal (manage)	cultural	There are cultural perceptions of what is ok to kill	cultural, civic	Killing rattlesnakes is seen as culturally acceptable in Idaho and people often lump in other species of snakes with that.
rules.legal (manage)	not hunting	Perception that ground squirrel hunting is different from big game	big game hunting, waterfowl	Many people don't think of shooting ground squirrels/whistle pigs as hunting - they view it as separate from hunting Big Game species or waterfowl.
management. actions	closures	General spatial or temporal closures	closures, close	Worst case - Could close areas, but there would be a huge backlash.
management. actions	ppl buffer	Specific closures within a buffer of power lines or transmission lines	powerline, buffer	Specific to powerlines: Could we close the area within a distance of powerline to protect the line and birds. Some kind of buffer. It wouldn't necessarily stop illegal killing but it would make it easier for Law Enforcement to prosecute.
management. actions	law enforcement	Increased law enforcement	law enforcement	Information is not taken seriously when it's given by researchers who are out on the

				ground - and generally the main official presence out there. Need people to see and talk to LE more often.
management. actions	consequences	Increase consequences or awareness of consequences	consequences, advertise	Increased advertising of powerline damage - it's vandalism, increases utility rates, and is a federal crime if it happens to lines that cross state lines
management. actions	education/ outreach	Spread information about rules in classrooms, public service announcement	education, outreach	Public service announcement - There is one currently. He doesn't think the target audience is going to be listening to public service announcements generally, but it's still important to try because they reach some people and word spreads.
management. actions	regulations	increased regulations for recreational use	regulate	Generally, regulate use more
management. actions	clean-up site	Clean up trash at the site to encourage others to pick up	trash, clean up	Could also implement a litter clean up

management.actions	management presence	Increase management presence at the site	management, presence, park ranger	Park rangers or someone who interacts one-on-one with recreationists. Right now, there's no one out there to hold people accountable or have a conversation.
management.actions	habitat restoration	Restore native vegetation/habitat	habitat, vegetation, native, sagebrush	Biggest is exotic grasses and changed fire cycle. Would like to see native sage and forbs. Right now, the area is very disturbed and has degraded noticeably over the years. A bonus is that restored habitat is also less ideal for shooters.
management.actions	non-toxic ammo	Require lead-free / non-toxic ammunition for people shooting	lead, ammunition	Another management action would be lead-free shooting areas - people would still be able to shoot, lead-free is easy to enforce (test using a magnet), this has been done in other areas of Idaho, it might be a bit more costly for users (but that could have a positive impact in reducing the number of shots

				taken during a day of shooting).
management. actions	signs/kiosks	Put up more signs at the NCA	sign, kiosk	Signage - They've tried this. It was a good first step, but signs get shot and vandalized
management. actions	travel plan	Implement a Travel and Access Management Plan	travel plant	Travel and Access Management Plan - Specific routes for vehicle types and seasonal closures. This would also help with managing/directing shooting use.
management. actions	organized shooting area	Create specific, organized areas for shooting	organize, designate	Organize shooting and have actual rules and regulations, actually structured. The current shooting at the site is unsafe.

Additional Recreation Survey Questions

We asked recreational shooters who participated in the online survey about their knowledge of shooting rules (*n = 19*). A majority of the online sample (85.7%) reported they had attended a Hunter Education course. We also asked shooters to identify which species are legal to shoot year-round without a permit or tag in Idaho (Figure A.5). Species that are legal to shoot were badgers, coyotes, ground squirrels, non-native songbirds, and jackrabbits. All other species are illegal to kill (birds of prey, native songbirds) or have some restrictions (corvids, rattlesnakes; Idaho Department of Fish and Game 2022). All shooters correctly identified that birds of prey, corvids, and native songbirds are not legal to shoot year-round without a permit or tag. The species that were incorrectly identified were all species that are legal to shoot – badgers (79% incorrect), non-native songbirds (68% incorrect), ground squirrels (53% incorrect), jackrabbits (53% incorrect), and coyotes (42% incorrect). The only species that is not legal to shoot year-round that was incorrectly identified was rattlesnakes (21% incorrect).

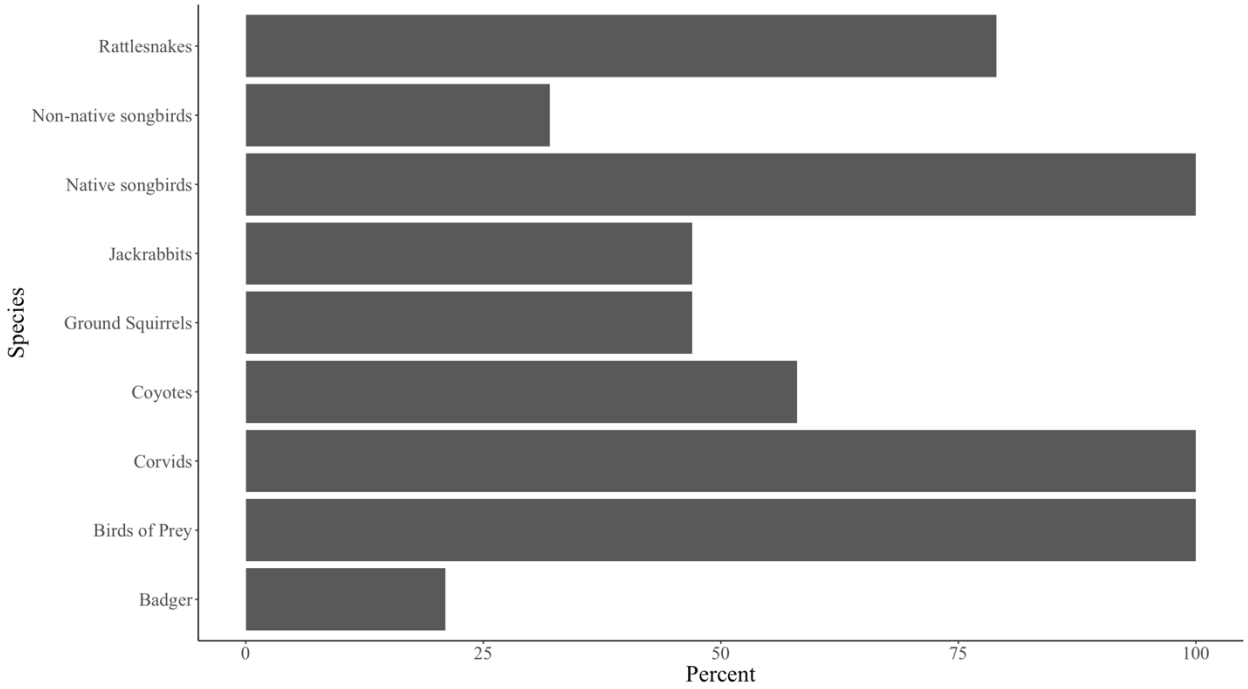


Figure A.5. The percentage of recreational shooters who participated in the online survey (*n* = 19) who correctly identified if a species could be shot legally year-round without a permit or tag in Idaho.

APPENDIX C: CHAPTER THREE SUPPLEMENTAL MATERIALS

Paired Site Comparison

We compared landscape characteristics of the paired high and low 1-km^2 sites to ensure that the groups did not differ significantly except for in recreational intensity. We summarized the landscape variables for each site in QGIS Geographic Information System (Version 3.16; QGIS Development Team 2022; Table A.5). We used the 2016 National Land Cover Database (Dewitz 2019) to derive the percent shrub cover, grassland cover, agriculture cover, and developed cover within each site. We calculated the straight-line distance from the center of each site to the Capitol Building in Boise, Idaho, the largest metropolitan area in the region. We summed the length (m) of roads and powerlines within each site, then divided by the site area (1 ha). We also compared the recreation intensity kernel density estimates for each site during the study period (March−July 2021) using all recreation groups, only shooting groups, only motorized recreation groups, and all other types of recreation groups. We tested for differences using a paired t-test or paired two-sample Wilcoxon test if the test failed a Shapiro-Wilk normality test. We used a $P \leq 0.05$ cutoff to determine significance.

Table A.5. Landscape variables for each 1-km^2 site at the Morley Nelson Snake River Birds of Prey National Conservation Area in southwestern Idaho. Sites are shown in high-low recreational use pairs.

Site ID	Shrub cover (%)	Grass cover (%)	Devel. cover (%)	Boise (km)	Road density (m/ha)	Powerline density (m/ha)	Rec. intensity full	Rec. intensity 2021	Shooting intensity 2021	Motorized intensity 2021	Other rec. intensity 2021
High1	3.7	92.8	3.6	26.0	28	4.96	$5.1x10^{-6}$	$1.9x10^{-6}$	$1.4x10^{-6}$	$2.9x10^{-7}$	$2.0x10^{-7}$
Low1	4.1	93.2	2.8	48.5	29	0.00	$1.6x10^{-7}$	$1.6x10^{-7}$	$1.6x10^{-7}$	$3.8x10^{-11}$	$2.7x10^{-25}$
High 2	41.0	59.0	0.0	28.6	1	0.00	$2.8x10^{-5}$	$9.5x10^{-6}$	$7.8x10^{-6}$	$8.0x10^{-7}$	$8.3x10^{-7}$
Low 2	29.6	70.4	0.0	52.2	15	0.00	$3.3x10^{-7}$	$1.4x10^{-7}$	$6.8x10^{-8}$	$7.5x10^{-8}$	$9.0x10^{-24}$
High 3	86.5	13.5	0.0	31.2	0	0.00	$4.1x10^{-6}$	$8.5x10^{-7}$	$7.3x10^{-7}$	$5.2x10^{-8}$	$6.8x10^{-8}$
Low 3	98.4	1.6	0.0	51.9	14	3.35	$3.4x10^{-7}$	$1.1x10^{-7}$	$1.1x10^{-22}$	$1.3x10^{-23}$	$1.1x10^{-7}$
High 4	0.1	99.1	0.0	34.9	0	5.45	$1.3x10^{-5}$	$4.2x10^{-6}$	$3.7x10^{-6}$	$2.1x10^{-7}$	$3.1x10^{-7}$
Low 4	0.0	100.0	0.0	60.1	7	2.20	$5.4x10^{-8}$	$9.0x10^{-12}$	$9.0x10^{-12}$	$5.8x10^{-16}$	$1.9x10^{-23}$
High 5	40.1	59.9	0.0	38.1	0	5.74	$8.0x10^{-6}$	$3.3x10^{-6}$	$2.4x10^{-6}$	$3.9x10^{-7}$	$5.8x10^{-7}$
Low 5	88.8	11.2	0.0	48.4	0	2.33	$9.2x10^{-8}$	$4.4x10^{-8}$	$3.0x10^{-8}$	$3.0x10^{-8}$	$5.7x10^{-16}$

Paired sites did not differ significantly for any landscape characteristic, with the exception of the distance to the Boise metropolitan center ($P = 0.002$; Table A.6). Because distance to the metropolitan area is a known predictor of habitat suitability for recreational use at the NCA (Pauli et al. 2019), we expected this variable to differ between high and low recreation sites. We expected that all sites were far enough from the metropolitan area (minimum distance = 26 km) to not impact any of the ecological variables of interest, so we did not change our site selection based on these results.

Table A.6. Comparison of site and landscape characteristics (mean + SD) for paired sites with high (n = 5) and low (n = 5) recreation at the Morley Nelson Snake River Birds of Prey National Conservation Area in southwestern Idaho. The range of values across the site, the mean difference, and the P-values are given for paired sample t-tests or two-sample Wilcoxon tests for each characteristic. An asterisk indicates significant differences.

Comparison	NCA values	High	Low	Mean difference	Test statistic	*P*-value
Area (ha) †	196,221	101.0 ± 0.0	101.4 ± 0.0	0.40	$V = 0.00$	0.346
Shrub cover (%)	35	34.3 ± 35.1	44.2 ± 46.7	9.91	$t = -0.96$	0.394
Grassland cover (%)	56	65.0 ± 34.3	55.3 ± 46.1	9.75	$t = 0.94$	0.402
Agriculture cover (%)	6	0	0	0		
Developed cover (%)	1	0.7 ± 1.6	0.6 ± 1.2	0.16	$V = 1.00$	1.000
Distance to Boise (km)		31.8 ± 4.8	52.2 ± 4.8	20.46	$t = -7.74$	0.002*
Density of roads (m/ha)	11	5.8 ± 12.4	13.0 ± 10.8	7.20	$t = -2.38$	0.076
Powerline density (m/ha)		3.2 ± 3.0	1.6 ± 1.5	1.65	$t = 1.11$	0.329
Recreation intensity (all)	2.0×10^{-7}	$1.2 \times 10^{-5} \pm 9.8 \times 10^{-6}$	$2.0 \times 10^{-7} \pm 1.3 \times 10^{-7}$	1.1×10^{-5}	$t = 2.62$	0.059

Recreation intensity (March - July 2021)	$6.7x10^{-8}$	$3.9x10^{-6} \pm 3.4x10^{-6}$	$9.1x10^{-8} \pm 6.7x10^{-8}$	$3.8x10^{-6}$	$t = 2.57$	0.062
Shooting intensity (March - July 2021)	$4.2x10^{-8}$	$3.2x10^{-6} \pm 2.8x10^{-6}$	$6.7x10^{-8} \pm 2.1x10^{-8}$	$3.2x10^{-6}$	$t = 2.50$	0.067
Motorized rec. intensity (March - July 2021)	$9.4x10^{-9}$	$3.5x10^{-7} \pm 2.8x10^{-7}$	$2.1x10^{-8} \pm 3.3x10^{-8}$	$3.3x10^{-7}$	$t = 2.93$	0.043*
Other rec. intensity (March - July 2021)	$1.5x10^{-8}$	$4.0x10^{-7} \pm 3.1x10^{-7}$	$2.3x10^{-8} \pm 5.0x10^{-8}$	$3.7x10^{-7}$	$t = 2.47$	0.069

Experimental Design Example

At each 1-km^2 site we established a 4 x 4 grid of 16 points spaced by 250 m, which were used for breeding bird point counts and raptor and raven surveys (Figure A.6). In the corner of each site, we placed 4 points spaced by 100 m for ground squirrel surveys. We placed two trail cameras per site approximately 250 m north and 250 m south of the center of site. We varied camera locations between sites to ensure that they were placed in a location that badgers were likely to use.

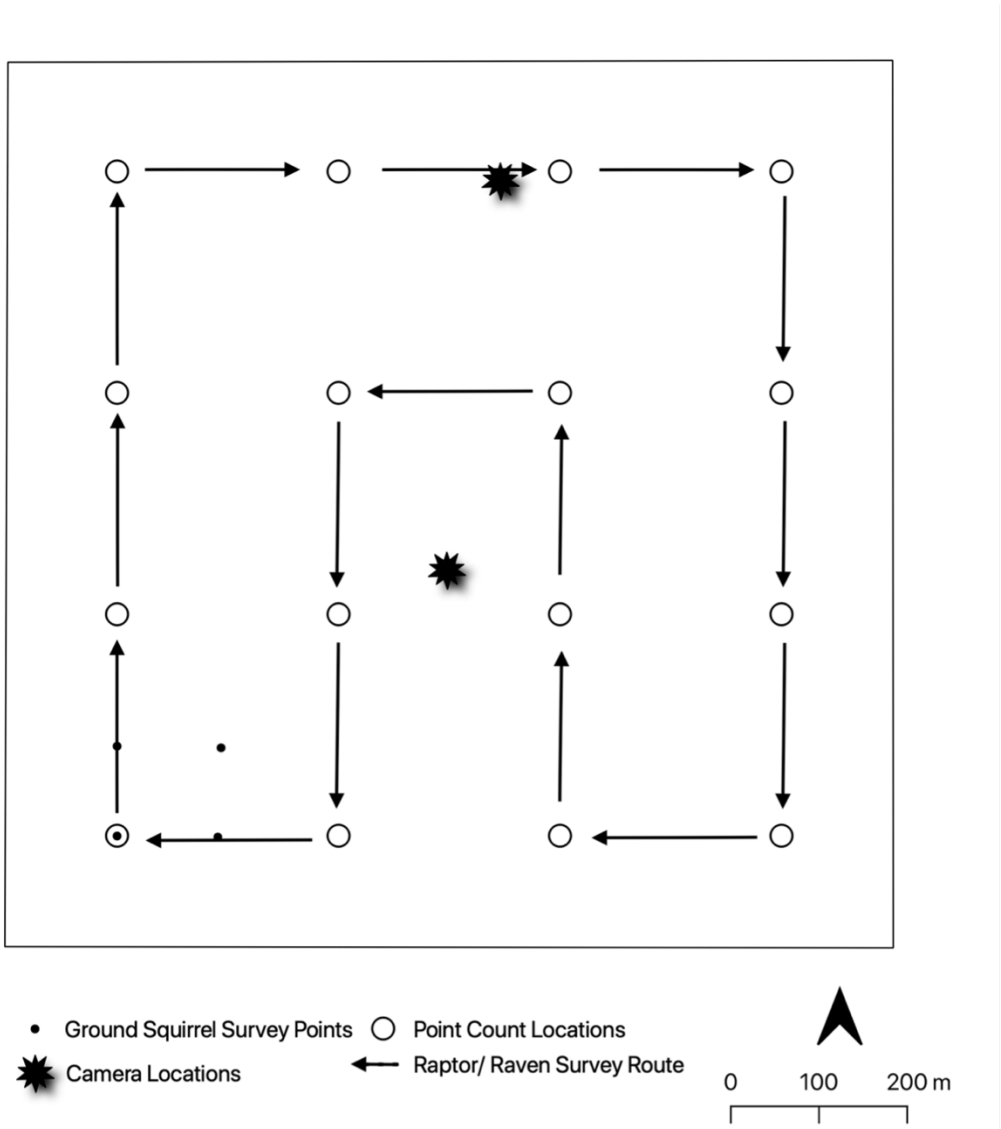


Figure A.6. Example design of ground squirrel surveys, breeding bird point counts, camera locations, and raptor and raven survey routes at a 1-km^2 site.

Nest Habitat Survey Details

Within 1 – 7 days of a nest fledging (horned larks) or hatching (long-billed curlews), we conducted a habitat survey at the nest and within a 10 m radius of the nest. We measured a set of parameters for each nest (Table A.7).

Table A.7. Parameters measured during habitat surveys at long-billed curlew and horned lark nests at the Morley Nelson Snake River Birds of Prey National Conservation Area in southwestern Idaho in 2019 – 2021.

Parameter	Description
Nest concealment	The number of dots visible on a ball (6.5 cm diameter) covered in a grid of dots from 1.5 m directly overhead and 1 m in each cardinal direction from a height of 0.5 m. % concealment = 1- (# visible dots / # total dots)
Nest orientation	The bearing from the center of the nest to a single clump of vegetation (e.g., one bunch of Great Basin rye grass), multiple clumps of vegetation (e.g., a patch of cheat grass), or another object (e.g., a cow pie, rock, or landscape feature). If a nest was in an open area or surrounded by vegetation on all sides, we recorded no orientation. We used a binary variable to represent the presence or absence of nest orientation in the model of horned lark nest success.
Terrestrial predator presence	We recorded the number of fresh ground squirrel and badger holes within a 10 m radius of the nest. Holes were considered fresh if the soil appeared to be recently disturbed and the hole was not filled with litter. We measured the distance to the nearest hole for both predator species.
Conspicuous objects	We counted the number of cow pies and rocks with a 10 cm or larger diameter within a 3 m radius from the nest.
Distance to road	We recorded the distance to the two nearest roads, road type, and the number of lanes. Distance was checked using QGIS and corrected if needed.

Additional Nest Monitoring Details

We considered a nest occupied if it was observed with eggs or chicks. At nest checks, we maintained as much distance as possible while still being able to see the nest and took precautions to reduce the risk of attracting predators, including not visiting nests late in the evening to avoid leaving a fresh scent trail to the nest and walking past the nest rather than creating a trail to and from the vantage point. When we found an empty,

completed nest but were not certain of its status, we recorded the location and checked the nest again in 2 – 3 days to see if any eggs had been laid. To avoid disturbing the birds during a sensitive stage in the nesting cycle, we first observed nests found during the building stage from 50 m or more, then approached the nest site after 4 – 7 days once laying was expected to have been completed.

For horned lark nests, we estimated initiation date, the day the first egg was laid, through observation of a nest that was found while building or laying, or by back-dating from a known hatch or fledge date. We assumed one egg was laid per day, an 11-day incubation period, and an 8-day nestling period (Camfield et al. 2010). To estimate fledgling age, we used a set of characteristics, including eyes opening, pin feather development, and contour feather eruption (Devin de Zwaan, Mount Allison University, personal communication). For nests where backdating was not possible (e.g., a nest was found with eggs but failed before hatching), we assumed the latest possible initiation date (i.e., clutch completed on the date found). When a nest failed between observations, we used the middle day as the failure date. We considered a horned lark nest successful if one or more fledglings left the nest.

We followed a similar protocol for long-billed curlews with the following exceptions. We estimated the initiation and expected hatch date by floating the eggs during our first visit (Liebezeit et al. 2007). Long-billed curlew chicks are precocial, so we ended our nest monitoring after hatching and considered the nest successful if one or more eggs hatched.

Table A.8. Full description of all nest habitat measures collected for horned larks and long-billed curlews.

Parameter	Description
Nest concealment	The number of dots visible on a ball (6.5 cm diameter) covered in a grid of dots from 1.5 m directly overhead and 1 m in each cardinal direction from a height of 0.5 m. **% concealment = 1- (# visible dots / # total dots)**
Effective Height	The height at which 90% of a white board (22 x 28 cm) is covered, 10 m from the nest in each cardinal direction.
Nest cup dimensions	The depth, length (North/South), and width (East/West) of a nest cup.
Nest decoration	The presence of nest decoration, such as stones or clumps of soil moved to the area. If present, the length and width of the area covered by the decoration and the number of discrete pieces.
Nest orientation	The bearing from the center of the nest to a single clump of vegetation (e.g., one bunch of Great Basin rye grass), multiple clumps of vegetation (e.g., a patch of cheat grass), or another object (e.g., a cow pie, rock, or landscape feature). If a nest was in an open area or surrounded by vegetation on all sides, we recorded no orientation.
Nearest perch	We looked within 400 m for up to two perches that could be used by aerial predators. We recorded the distance, height, and type of perch.
Terrestrial predator presence	We recorded the number of fresh ground squirrel and badger holes within a 10 m radius of the nest. Holes were considered fresh if the soil appeared to be recently disturbed and the hole was not filled with litter. We measured the distance to the nearest hole for both species.
Conspicuous objects	We counted the number of cow pies and rocks with a 10 cm or larger diameter within a 3 m radius from the nest.
Nearest cover	We recorded the distance to the nearest cover that would be tall and dense enough to conceal recently fledged chicks. The type of cover was also recorded.
Soil crust	We recorded the presence of soil crust within a 10 m radius of the nest.

Flood risk and aspect	We recorded the potential for flooding in non-catastrophic events. We also recorded if the area was flat or on a hill. If on a hill, we recorded the compass bearing of the hill face around the nest.
Distance to road	We recorded the distance to the two nearest roads, road type, and the number of lanes. Distance was checked using QGIS and corrected if needed.
Vegetation	We classified the vegetation within 10 m of the nest by ranking the most dominant cover type (grass, forbs, shrubs, other) and listing the two most dominant species within each cover type.

Point Count Summaries

Bird Detections

Table A.9. Detections of all species during our April breeding bird point counts in total and summarized by site* as the number of detections (number of individuals). The counts were focused on horned larks and long-billed curlews, so the timing of the counts was prior to the breeding season for some species.

Species	Total	High 1	Low1	High 2	Low 2	High 3	Low 3	High 4	Low 4	High 5	Low 5
Common Raven *Corvus corax*	346 (465)	44 (70)	24 (28)	45 (56)	16 (18)	52 (72)	32 (47)	54 (65)	19 (21)	26 (42)	34 (46)
Horned Lark *Eremophila alpestris*	324 (426)	28 (31)	71 (163)	6 (6)	24 (25)	37 (40)	64 (64)	1 (1)	60 (61)	2 (2)	31 (33)
Long-billed Curlew *Numenius americanus*	130 (141)	29 (30)	50 (59)	14 (14)	4 (5)	1 (1)	0	0	26 (26)	6 (6)	0
Northern Harrier *Circus hudsonius*	54 (56)	10 (11)	6 (6)	3 (3)	2 (2)	11 (11)	1 (1)	7 (7)	0	13 (14)	1 (1)
Western Meadowlark *Sturnella neglecta*	46 (47)	0	35 (36)	1 (1)	7 (7)	2 (2)	0	0	0	0	1 (1)
Sagebrush Sparrow *Artemisiospiza nevadensis*	44 (44)	0	0 (0)	9 (9)	0	34 (34)	1 (1)	0	0	0	0

Red-tailed Hawk *Buteo jamaicensis*	34 (37)	12 (14)	2 (2)	5 (5)	1 (1)	10 (10)	4 (5)	0	0	0	0
Burrowing Owl *Athene cunicularia*	20 (20)	0	14 (14)	0	3 (3)	0	1 (1)	0	2 (2)	0	0
Rough-legged Hawk *Buteo lagopus*	17 (17)	6 (6)	2 (2)	0	0	5 (5)	2 (2)	1 (1)	0	0	1 (1)
Swainson's Hawk *Buteo swainsoni*	16 (16)	8 (8)	0	1 (1)	0	5 (5)	1 (1)	1 (1)	0	0	0
Ferruginous Hawk *Buteo regalis*	9 (9)	1 (1)	1 (1)	0	0	0	3 (3)	0	0	1 (1)	3 (3)
Prairie Falcon *Falco mexicanus*	8 (8)	0	0	0	1 (1)	0	5 (5)	1 (1)	0	0	1 (1)
American Kestrel *Falco sparverius*	6 (6)	0	0	0	0	0	6 (6)	0	0	0	0
Turkey Vulture *Cathartes aura*	5 (8)	1 (1)	1 (1)	0	0	0	0	0	0	0	3 (6)

Savannah Sparrow *Passerculus sandwichensis*	5 (6)	2 (2)	3 (4)	0	0	0	0	0	0	0	0
White-crowned Sparrow *Zonotrichia leucophrys*	4 (4)	0	0	2 (2)	0	0	0	2 (2)	0	0	0
Eurasian Starling *Sturnus vulgaris*	3 (16)	2 (15)	1 (1)	0	0	0	0	0	0	0	0
Brewer's Sparrow *Spizella breweri*	3 (3)	0	0	0	0	3 (3)	0	0	0	0	0
White-crowned Sparrow (Gambel's)	3 (3)	3 (3)	0	0	0	0	0	0	0	0	0
Unknown Raptor	3 (3)	1 (1)	0	0	0	0	0	2 (2)	0	0	0
Golden Eagle *Aquila chrysaetos*	2 (2)	1 (1)	0	0	0	1 (1)	0	0	0	0	0
Loggerhead Shrike *Lanius ludovicianus*	2 (2)	0	1 (1)	0	0	0	1 (1)	0	0	0	0

Ring-billed Gull *Larus delawarensis*	1 (12)	0	0	0	0	0	1 (12)	0	0	0	0
Townsend's Solitaire *Myadestes townsendi*	1 (5)	0	0	0	0	0	0	0	0	0	1 (5)
Rock Pigeon *Columba livia*	1 (4)	1 (4)	0	0	0	0	0	0	0	0	0
California Gull *Larus californicus*	1 (2)	0	0	0	0	0	1 (2)	0	0	0	0
Franklin’s Gull Leucophaeus pipixcan	1 (2)	0	0	0	0	0	1 (2)	0	0	0	0
Killdeer *Charadrius vociferus*	1 (2)	1 (2)	0	0	0	0	0	0	0	0	0
Mountain Bluebird *Sialia currucoides*	1 (1)	0	0	0	0	1 (1)	0	0	0	0	0
Say’s Phoebe *Sayornis saya*	1 (1)	1 (1)	0	0	0	0	0	0	0	0	0

Snow Goose *Chen caerulescens*	1 (1)	0	0	0	1 (1)	0	0	0	0	0	0
Spotted Towhee *Pipilo maculatus*	1 (1)	0	0	1 (1)	0	0	0	0	0	0	0
Unknown Swallow	1 (2)	0	0	0	0	1 (2)	0	0	0	0	0
Unknown Bird	1 (1)	0	0	1 (1)	0	0	0	0	0	0	

Vegetation

Table A.10. Vegetation data collected during our April breeding bird point counts summarized by site.

Vegetation	Total	High 1	Low 1	High 2	Low 2	High 3	Low 3	High 4	Low 4	High 5	Low 5
Habitat Type (% of pts)											
Barren	15.6	0	0	0	0	0	0	56.3	100	0	0
Desert Shrubland	8.1	0	0	0	0	0	81.3	0	0	0	0
Grassland	11.2	6.2	25.0	6.2	0	0	0	12.5	0	62.5	0
Herbaceous Meadow	24.4	37.5	56.3	62.5	62.5	0	0	25.0	0	0	0
Sage Shrubland	11.9	0	12.5	31.3	37.5	0	0	0	0	37.5	0
Shrubland	28.7	56.3	6.2	0	0	100	18.7	6.2	0	0	100
% Shrub Cover* (Mean ± SD)	4.8 ± 6.5	7.1 ± 4.0	2.4 ± 5.4	6.4 ± 8.5	5.4 ± 5.5	11.6 ± 7.0	3.5 ± 4.0	2.4 ± 2.8	0.0 ± 0.0	7.6 ± 10.2	1.3 ± 1.5
% Herbaceous Cover (Mean ± SD)	7.3 ± 9.5	10.9 ± 3.8	11.7 ± 7.3	6.7 ± 3.3	26.6 ± 14.9	8.8 ± 2.7	1.0 ± 0.0	4.5 ± 3.7	0.1 ± 0.3	2.4 ± 3.6	0.3 ± 0.4
% Grass Cover** (Mean ± SD)	6.0 ± 11.4	2.9 ± 2.5	6.2 ± 5.5	1.8 ± 2.7	1.2 ± 2.4	3.0 ± 1.8	1.0 ± 0.0	5.6 ± 2.7	1.8 ± 0.5	35.1 ± 16.5	1.1 ± 0.3

* Does not include shrubs < 0.25 m tall, which includes winterfat and other shrubs that could be considered shrubland.

** Includes live grasses and standing dead grasses.

Raptor and Raven Summaries

Table A.11. Raptor and raven detections by site during May – July surveys. Detections are totaled across 8 visits per site.

Species	Total	High 1	Low 1	High 2	Low 2	High 3	Low 3	High 4	Low 4	High 5	Low 5
Burrowing Owl *A. cunicularia*	17	0	2	1	8	1	0	0	0	0	5
*Buteo**	60	24	7	4	2	1	3	8	3	8	0
Ferruginous Hawk *B. regalis*	7	0	0	0	0	0	1	2	3	1	0
Red-Tailed Hawk *B. jamaicensis*	30	11	7	3	1	0	1	4	0	3	0
Swainson's Hawk *B. swainsoni*	17	13	0	1	0	0	0	1	0	2	0
Common Raven *C. corax*	303	54	33	44	38	8	11	65	6	34	10
Golden Eagle *A. chrysaetos*	7	1	0	1	3	0	0	1	1	0	0

Northern Harrier *C. hudsonius*	64	8	6	8	10	1	6	7	3	5	10
Prairie Falcon *F. mexicanus*	22	6	2	4	0	0	0	4	0	6	0
Turkey Vulture *C. aura*	6	3	0	1	0	1	0	0	0	1	0
Short-eared Owls *A. flammeus*	3	0	0	0	0	0	0	0	0	3	0

* *Buteo* category includes raptors that could not be identified past the genus.

APPENDIX D: PILOT SEASON SUMMARY

In 2019, we implemented a pilot survey of recreational shooters and other recreationists in southwest Idaho. We administered surveys on-site in two locations. We surveyed all recreationists at the Morley Nelson Snake River Birds of Prey National Conservation Area (NCA) in southwest Idaho from 19 April to 20 July 2019 using two survey instruments. The first included all survey questions and was given to recreational shooters ("NCA Long"), while the second contained a subset of questions for all recreationists or shooters who did not have time for the longer version ("NCA Short"). The second survey location was the Black's Creek Public Shooting Range from 18 May to 23 July 2019 to sample recreational shooters who use a different shooting venue. Results from the pilot season (Table D.1) were used to refine hypotheses and design the survey instruments used in Chapters 1 and 2.

Table A.12. Results of pilot surveys distributed at the Morley Nelson Snake River National Conservation Area (NCA) and Black's Creek Public Shooting Range in 2019. Questions that were not asked in a particular survey are left blank. The "NCA Total" column summarizes the results of the short and long surveys administered at the NCA. In cases where not all participants answered a question, summary statistics are based on the number of responses received.

Question	Overall	NCA Total	NCA Short	NCA Long	Black's Creek
Sample Size	75	43	15	28	32
Response Rate (%)	30.0	30.9	-	-	28.8
Survey Participant Demographics					
Respondent Gender % (n)					
Male	83 (62)	86 (37)	80 (12)	89 (25)	78 (25)
Female	17 (13)	14 (6)	20 (3)	11 (3)	22 (7)
Age (mean ± SD)	51.4 ± 16.0			51.6 ± 15.0	51.3 ± 17.1
Youngest	21	-	-	21	24
Oldest	83			77	83
Residence					
Treasure Valley	96 (72)	93 (40)	80 (12)	100 (28)	100 (32)
Other Idaho	3 (2)	5 (2)	13 (2)	0 (0)	0 (0)
Out of State	1 (1)	2 (1)	7 (1)	0 (0)	0 (0)

County (For Idahoans)					
Ada County	84 (47)			77 (20)	90 (27)
Adams County	2 (1)			4 (1)	0 (0)
Canyon County	7 (4)	-	-	11 (3)	3 (1)
Kuna County	2 (1)			4 (1)	0 (0)
Elmore County	3 (2)			0 (0)	7 (2)
Payette County	2 (1)			4 (1)	0 (0)
Years at current residence (mean ± SD)	9.9 ± 10.8	-	-	9.2 ± 8.3	10.6 ± 12.8
Number of People in Household (mean ± SD)	2.7 ± 1.6	-	-	3.0 ± 1.7	2.6 ± 1.5
Annual Household Income					
Less than $25k	4 (2)			0 (0)	7 (2)
$26 - 50k	19 (10)			20 (5)	17 (5)
$51 - 75k	15 (8)	-	-	16 (4)	14 (4)
$76 - 100k	11 (6)			8 (2)	14 (4)
$101 - 150k	31 (17)			32 (8)	31 (9)
Over $151k	20 (11)			24 (6)	17 (5)

Education Level					
High School /GED	20 (12)			25 (7)	16 (5)
Associate Degree	27 (16)	-	-	29 (8)	25 (8)
Bachelor's Degree	35 (21)			39 (11)	31 (10)
Graduate Degree	18 (11)			7 (2)	28 (9)

Basic Information About Visit					
Group Size (mean ± SD)	1.9 ± 1.1	2.3 ±1.2	2.0 ± 1.2	2.4 ± 1.3	1.5 ± 0.7
Group Composition					
Unknown	1 (1)	2 (1)	7 (1)	0 (0)	0 (0)
1 Male	39 (29)	33 (14)	33 (5)	32 (9)	47 (15)
2 Males	14 (10)	10 (4)	20 (3)	4 (1)	19 (6)
3 Males	3 (2)	2 (1)	0 (0)	4 (1)	3 (1)
4 Males	4 (3)	7 (3)	0 (0)	11 (3)	0 (0)
1 Female	10 (7)	2 (1)	7 (1)	0 (0)	19 (6)
2 Females	3 (2)	2 (1)	7 (1)	0 (0)	3 (1)
1 Male & 1 Female	14 (10)	24 (10)	20 (3)	25 (7)	0 (0)
2 Males & 1 Female	1 (1)	2 (1)	0 (0)	4 (1)	0 (0)
2 Males & 2 Females	3 (2)	5 (2)	7 (1)	4 (1)	0 (0)
3 Males & 1 Female	1 (1)	2 (1)	0 (0)	4 (1)	0 (0)
3 Males & 2 Females	1 (1)	2 (1)	0 (0)	4 (1)	0 (0)
1 Male, 1 Female & 1 Kid	4 (3)	2 (1)	0 (0)	4 (1)	6 (2)
1 Male, 1 Female & 2 Kids	1 (1)	2 (1)	0 (0)	4 (1)	0 (0)
2 Males &1 Kid	1 (1)	0 (0)	0 (0)	0 (0)	3 (1)

Activity*					
Biking		2 (1)	0 (0)	4 (1)	
Bird Watching		12 (5)	27 (4)	4 (1)	
Hiking		12 (5)	27 (4)	4 (1)	
Target Shooting	-	60 (26)	53 (8)	64 (18)	-
Ground Squirrel Shooting		26 (11)	47 (7)	14 (4)	
Sighting-in Riffle		19 (8)	13 (2)	21 (6)	
Other Shooting		2 (1)	0 (0)	4 (1)	
Other		26 (11)	27 (4)	25 (7)	
Other write in:	*Archery, collecting brass, drawing, exercise, fishing, getting out of the city, harmonica playing, motorcycling, photography, radio direction finding, walking along the river at Swan Falls Dam*				
Hours Spent Recreating	3.7 ± 4.5	3.3 ± 2.7	3.7 ± 2.9	3.1 ± 2.6	4.0 ± 5.8
Squirrels Shot (mean ± SD)		0.6 ± 0.5	13.5 ± 19.5	0.5 ± 0.7	
Minimum	-	0	0	0	-
Maximum		50	50	1	

Recreation Experience					
Do you see military personnel while shooting? % (n)					
Yes	-	34 (13)	43 (6)	29 (7)	-
No		66 (25)	57 (8)	71 (17)	
Does seeing the military affect your experience?					
Negatively	-	0 (0)	0 (0)	0 (0)	-
Not at All		69 (9)	100 (6)	43 (3)	
Positively		31 (4)	0 (0)	57 (4)	
Military comments:	[1] *Depends on the situation.*				
Do you see other recreational users while recreating? % (n)					
Yes	-	90 (19)	86 (12)	100 (14)	-
No		10 (2)	14 (2)	0 (0)	

Does seeing other users affect your experience?					
Negatively	-	16 (5)	18 (2)	14 (3)	-
Not at All		68 (22)	82 (9)	62 (13)	
Positively		16 (5)	0 (0)	24 (5)	
Other recreationist comments:	[1] *Sometimes negative when they leave trash.* [2] *Varies greatly.*				
Participation in Recreational Shooting					
Recreational Shooting % (n)	95 (56)	-	-	96 (27)	91 (29)
Indoor shooting range % (n)	58 (34)	-	-	54 (15)	59 (19)
Outdoor shooting range % (n)	83 (49)	-	-	71 (20)	91 (29)
Outdoor, not at a range % (n)	69 (41)	-	-	89 (25)	50 (16)
Ground squirrel shooting % (n)	47 (28)	-	-	61 (17)	34 (11)
Other varmint hunting % (n)	17 (10)	-	-	21 (6)	13 (4)
Other varmints write in:	*All, ducks in season, deer, elk, game animals, rock chucks (marmots), badgers, coyote, fox, bobcat, anything with a hunting season, sheep, chukar, starlings*				
Sighting in rifle for hunting % (n)	58 (34)	-	-	68 (19)	41 (13)

Hunting practice % (n)	56 (33)	-	-	68 (19)	44 (14)
Other Shooting % (n)	22 (13)	-	-	29 (8)	16 (5)
Other shooting write in:	*Fun, general practice, long range shooting (400 – 1000 yards), militia training, sport clay shooting, competition, exercise 2nd Amendment, load development*				
Years shooting (mean ± SD)	28.9 ± 17.8			31.0 ± 17.8	27.1 ± 17.9
Minimum	1	-	-	1	2
Maximum	60			60	60
Hours spent shooting (mean ± SD)	3.7 ± 4.6			3.5 ± 2.7	4.0 ± 5.8
Minimum	1	-	-	1	1
Maximum	35			13	35
Preferred group size	3.5 ± 4.2	-	-	3.6 ± 2.4	3.3 ± 5.5
Shoot with % (n): *					
Alone	27 (16)			29 (8)	29 (8)
Family	47 (28)			57 (16)	43 (12)
Friends	59 (35)	-	-	61 (17)	64 (18)
Friends & Family	36 (21)			39 (11)	36 (10)
Other	8 (5)			11 (3)	7 (2)

Other shooting companion write in:	*Dog, militia members and public participants, students*
Caliber (bolded are at Black's Creek)	[1] *Whatever is available,* [2] *22 LR, 223, 22 – 250, 66mm Rem,* [3] *22, 223, 5.56, 308, 50, 45, 9mm, 30, 40,* [4] *22, 410, 5.56,* [5] *Many*, [6] *30, shotgun,* [7] *.22 LR, .223,* [8] *9mm, 10mm, 223, 12 gauge, 50 mng,* [9] *9mm, .22, 5.56,* [10] *.22, -.17,* [11] *9mm, 380, .22,* [12] *.22 – 7mm,* [13] *.223 – 5.56, 22/250-.22, -.9mm, -.95ocp, -45LC, -357, -.44,* [14] *9mm, 45, .300 Blaubout, 6.5 Cremon,* [15] *40, 380,* [16] *9mm, .22,* [17] *22LR,* [18] *5.56, 22LR, 12GA,* [19] *.556, 9mm, 45ACP,* [20] *.22,* [21] *.22,* [22] *.22, 7mao8,* [23] *25 odd 6, 7mm, 35 Marlin, 3030, 223, 44 Magnum, 357, 9mm, 2-gauge shotgun, 22 hideways,* [24] *.30, 9mm, 10mm,* [25] *varies*, [26] *22LR, 6.5cm, 12 gauge,* [27] *.224, 145, .270, .308, 12* **[28] *.308, 45,* [29] *22, 44,* [30] *40 – 65,* [31] *6.5 creed, 300 WM, 22LR, 20g, 12g,* [32] *9mm, 10mm, .30 – 06,* [33] *223,* [34] *.22, 9mm, 45,* [35] *223, 9, 45,* [36] *.22,* [37] *556, 223, 9mm,* [38] *9mm, 50 BMG, .308,* [39] *.22,* [40] *.38,* [41] .17, 45, .22, [42] *.22,* [43] *270, 380,* [44] *.22, .30,* [45] *.45, .22,* [46] *300, 223, .22,* [47] *308, 223, 38 special, 45 ACP, 9mm,* [48] *Too many to list,* [49] *.223,* [50] *308, 556, 6.5 creedam,* [51] *.22, .223, 6.5,* [52] *.38, 9mm, 45, .22, 308, 22-250***

Gun (bolded are at Black's Creek)	[1] *Glock, shotgun,* [2] *Blot, semi-automatic*, [3] *Many*, [4] *Rifle*, [5] *Ruger 10/22, Winchester mdl. 70,* [6] *Pistols, rifles*, [7] *Rifle/pistol*, [8] *Savage or Ruger*, [9] *Handguns, rifles*, [10] *All types*, [11] *All*, [12] *Handgun, all,* [13] *Ruger, semi-automatic, Hadger,* [14] *Sig*, [15] *Pistol*, [16] *Rifles, handguns, shotguns,* [17] *22*, [18] *Rifle/pistol*, [19] *22 odd 6, 7mm, 35 Marlin, 3030, 223, 44 Magnum, 357, 9mm, 2 gauge shotgun, 22 hideaways,* [20] *Bold action, rifle, semi-automatic handgun*, [21] *Many types,* [22] *Rifles*, [23] *AR-15, 1911, Seiko, Saiga***[24] *Ruger,* [25] *Rifle, pistol,* [26] *BPCR rifle,* [27] *Rifle, shotgun,* [28] *Glock, pistol, Remington, rifle,*[29] *AR, rifles, pistols,* [30] *Rifle,* [31] *Bolts gun, AR,* [32] *9mm, 45, .22,* [33] *Handgun,* [34] *9mm, AR,* [35] *Pistol, AR-15,* [36] *.22, shotgun,* [37] *Bolt Action,* [38] *9mm, 45, .22,* [39] *Handgun,* [40] *9mm, AR,* [41] *Barrett, SCAR-H,* [42] *9mm,* [43] *Sig,* [44] *Rifle,* [45] *Rifle,* [46] *Winchester,* [47] *Rifle,* [48] *Handgun,* [49] *All,* [50] Various, [51] *Too many to list,* [52] *Bolt long gun,* [53] *Rifle,* [54] *Rifle,* [55] *Shotgun, pistol*				
How often do you shoot ground squirrels/other live targets? % (n)					
Never	47 (27)	-	-	38 (10)	55 (17)
Every 2+ years	10 (6)			7 (2)	13 (4)
1 -2 x per year	19 (11)			26 (7)	13 (4)
1-2 x per month	21 (12)			22 (6)	19 (6)
1-2 x per week	3 (2)			7 (2)	0 (0)
Nearly every day	0 (0)			0 (0)	0 (0)

How often do you go shooting at a range? % (n)					
Never	9 (5)			15 (4)	3 (1)
Every 2+ years	12 (7)			15 (4)	10 (3)
1 -2 x per year	29 (17)	-	-	37 (10)	22 (7)
1-2 x per month	38 (22)			22 (6)	52 (16)
1-2 x per week	12 (7)			11 (3)	13 (4)
Nearly every day	0 (0)			0 (0)	0 (0)
How often do you shoot at the NCA? % (n)					
Never				7 (2)	
Every 2+ years				7 (2)	
1 -2 x per year	-	-	-	38 (10)	-
1-2 x per month				33 (9)	
1-2 x per week				11 (3)	
Nearly every day				4 (1)	

Knowledge of Rules & Regulations					
Have you attended Hunter Education? % (n)	66 (39)	-	-	71 (20)	61 (19)
Years since Hunter Education (mean ± SD)	27.6 ± 17.4	-	-	33.6 ± 15.3	22.8 ± 17.9
You need a hunting license to shoot live targets in Idaho. % (n)					
True (correct)	71 (42)	-	-	71 (20)	71 (22)
False (incorrect)	29 (17)			29 (8)	29 (9)
You need a permit to use spotlights to shoot live targets at night. % (n)					
True (correct)	60 (29)	-	-	57 (13)	64 (16)
False (incorrect)	40 (19)			43 (10)	36 (9)

Which of the following species are legal to shoot year-round without a permit in Idaho? Correct answers % (n)					
Piute ground squirrels	96 (52)			96 (26)	96 (26)
Coyotes	87 (47)	-	-	78 (21)	96 (26)
Birds of Prey	98 (53)			100 (27)	96 (26)
Badgers	55 (29)			54 (14)	56 (15)
Jackrabbits	81 (43)			85 (22)	78 (21)
Native songbirds	96 (52)			93 (25)	100 (27)
Corvids	79 (37)			83 (19)	75 (18)
Where do you get your information about shooting rules and regulations?		-	-		
Idaho Dept. of Fish & Game	58 (33)			54 (15)	62 (18)
Other sources of information:	*Hunter Education, books, friends, guessing, Idaho.org type of websites, online, sport shops, the state's websites, YouTube, Idaho.gov, ATF, NRA, no idea, hunting regulations, Idaho state media, booklets/brochures, word of mouth*				

How important is it to you to follow rules & regulations while shooting?					
Not important	0 (0)	-	-	0 (0)	0 (0)
Somewhat important	0 (0)			0 (0)	0 (0)
Very important	100 (59)			100 (28)	100 (31)
How likely would you be to report someone you saw breaking a law while shooting?					
Not likely	7 (4)	-	-	12 (3)	3 (1)
Somewhat likely	30 (17)			23 (6)	35 (11)
Very likely	63 (36)			65 (17)	61 (19)

Place Attachment					
The areas where I shoot mean a lot to me.					
Strongly disagree	5 (3)			7 (2)	3 (1)
Disagree	0 (0)	-	-	0 (0)	0 (0)
Neutral	8 (5)			7 (2)	9 (3)
Agree	23 (14)			18 (5)	28 (9)
Strongly agree	63 (38)			68 (19)	59 (19)
I would not substitute any other place for my local shooting area.					
Strongly disagree	13 (8)			18 (5)	9 (3)
Disagree	13 (8)	-	-	14 (4)	13 (4)
Neutral	35 (21)			25 (7)	44 (14)
Agree	12 (7)			14 (4)	9 (3)
Strongly agree	27 (16)			29 (8)	25 (8)

I feel happiest when I am in the areas where I shoot.					
Strongly disagree	8 (5)			11 (3)	6 (2)
Disagree	5 (3)	-	-	0 (0)	9 (3)
Neutral	30 (18)			29 (8)	31 (10)
Agree	30 (18)			32 (9)	28 (9)
Strongly agree	27 (16)			29 (8)	25 (8)
I have a special connection to the place where I go shooting and the people in that area.					
Strongly disagree	5 (3)			4 (1)	6 (2)
Disagree	8 (5)	-	-	7 (2)	9 (3)
Neutral	35 (21)			36 (10)	34 (11)
Agree	30 (18)			29 (8)	31 (10)
Strongly agree	22 (13)			25 (7)	19 (6)

Place meaning – sociocultural					
The area where I shoot has many people who share my values.					
Strongly disagree	2 (1)			0 (0)	3 (1)
Disagree	7 (4)	-	-	7 (2)	6 (2)
Neutral	22 (13)			29 (8)	16 (5)
Agree	40 (24)			25 (7)	53 (17)
Strongly agree	30 (18)			39 (11)	22 (7)
The area where I shoot has many people whose company I enjoy.					
Strongly disagree	3 (2)			0 (0)	6 (2)
Disagree	20 (12)	-	-	11 (3)	28 (9)
Neutral	25 (15)			37 (10)	16 (5)
Agree	37 (22)			37 (10)	38 (12)
Strongly agree	14 (8)			15 (4)	13 (4)

The area where I shoot is a close-knit community.					
Strongly disagree	3 (2)			7 (2)	0 (0)
Disagree	20 (12)	-	-	18 (5)	22 (7)
Neutral	42 (25)			43 (12)	41 (13)
Agree	25 (15)			21 (6)	28 (9)
Strongly agree	10 (6)			11 (3)	9 (3)
Place meaning – environmental					
The area where I shoot is beautiful and scenic.					
Strongly disagree	0 (0)			0 (0)	0 (0)
Disagree	8 (5)	-	-	11 (3)	6 (2)
Neutral	23 (14)			25 (7)	22 (7)
Agree	40 (24)			32 (9)	47 (15)
Strongly agree	28 (17)			32 (9)	25 (8)

The area where I shoot feels like home.					
Strongly disagree	5 (3)			7 (2)	3 (1)
Disagree	13 (8)	-	-	14 (4)	13 (4)
Neutral	28 (17)			14 (4)	41 (13)
Agree	25 (15)			36 (10)	16 (5)
Strongly agree	28 (17)			29 (8)	28 (9)
The area where I shoot has a high-quality environment.					
Strongly disagree	0 (0)			0 (0)	0 (0)
Disagree	10 (6)	-	-	11 (3)	9 (3)
Neutral	33 (20)			36 (10)	31 (10)
Agree	28 (17)			29 (8)	28 (9)
Strongly agree	28 (17)			25 (7)	31 (10)

Environmental Norms					
Most people in my shooting community think it is important to protect the natural environment.					
Strongly disagree	0 (0)			0 (0)	0 (0)
Disagree	2 (1)	-	-	4 (1)	0 (0)
Neutral	17 (10)			15 (4)	19 (6)
Agree	32 (19)			30 (8)	34 (11)
Strongly agree	49 (29)			52 (14)	47 (15)
Most people in my shooting community engage in activities that help protect the environment.					
Strongly disagree	0 (0)			0 (0)	0 (0)
Disagree	3 (2)	-	-	0 (0)	6 (2)
Neutral	33 (19)			31 (8)	34 (11)
Agree	40 (23)			38 (10)	41 (13)
Strongly agree	24 (14)			31 (8)	19 (6)

Environmental Concern					
The natural environment in the area where I shoot is threatened by human activities.					
Strongly disagree	5 (3)	-	-	7 (2)	3 (1)
Disagree	27 (16)			30 (8)	25 (8)
Neutral	37 (22)			37 (10)	38 (12)
Agree	15 (9)			11 (3)	19 (6)
Strongly agree	15 (9)			15 (4)	16 (5)
The natural environment in the area where I shoot is currently suffering ecological damage.					
Strongly disagree	17 (10)	-	-	19 (5)	16 (5)
Disagree	24 (14)			26 (7)	22 (7)
Neutral	36 (21)			22 (6)	47 (15)
Agree	15 (9)			22 (6)	9 (3)
Strongly agree	8 (5)			11 (3)	6 (2)
Open-ended comments:	[1] *Some of my kids like shooting, others don't. I don't force them. Teaching safety is my top priority.* [2] *Pheasant hunting is most definitely threatened by human activity. Gun ranges may soon be threatened due to increases in Idaho population.*				

APPENDIX E: ONLINE SURVEY MATERIALS – RECREATIONAL SHOOTING IN THE TREASURE VALLEY

The purpose of this survey is to learn about the experiences, preferences, and concerns of recreational shooters in the Treasure Valley. You are being asked to take this survey to share your experiences with recreational shooting. Your responses will help to better inform management agencies about the priorities of recreational shooters in the Treasure Valley.

Survey participation is voluntary. The survey will take approximately 10 minutes or less to complete.

You must be at least 18 years old to take this survey.

This study involves no foreseeable serious risks. The researchers will make every effort to protect your confidentiality. However, the researchers are requesting demographic information. Due to the make-up of Idaho's population, the combined answers to these questions may make an individual person identifiable.

We ask that you try to answer all questions; however, you may choose to skip any question you do not wish to answer. You are free to stop the survey and clear your responses at any time.

Your confidentiality will be maintained to the degree permitted by the technology used. Specifically, no guarantees can be made regarding the interception of data sent via the Internet by any third parties. We will protect your confidentiality and anonymity by transferring and storing responses in an encrypted form. We will not store your IP address or other identifiable data with your survey response. In reports and publications, responses will be displayed in aggregate form.

If you have any questions or concerns, feel free to contact Madeline or her faculty advisor:

Madeline Aberg, graduate student
Biological Sciences
(641) 590-5554
madelineaberg@boisestate.edu

Dr. Jay Carlisle, Research Professor
Biological Sciences
(208) 426-5203
jaycarlisle@boisestate.edu

If you have questions about your rights as a research participant, you may contact the Boise State University Institutional Review Board, which is concerned with the protection of volunteers in research projects and has reviewed and approved this survey. The IRB protocol number is 001-SB19-045. You may reach the board office between 8:00 AM and 5:00 PM, Monday through Friday, by calling (208) 426-5401 or by writing: Institutional Review Board, Office of Research Compliance, Boise State University, 1910 University Dr., Boise, ID 83725-1138.

Do you consent to participating in this survey?

Answer options (must respond to proceed):

Yes, I consent → *begin survey*

No, I do not consent → *end survey*

This survey is focused on the experiences of recreational shooters in the Treasure Valley in southwestern Idaho.

Throughout the survey, the term "recreational shooting" is used to refer to a variety of activities, including:

- Shooting "varmint" species (ground squirrels/ "whistle pigs," marmots/"rock chucks," coyotes, badgers)
- Shooting targets
- Sighting-in rifle
- Shooting clay pigeons

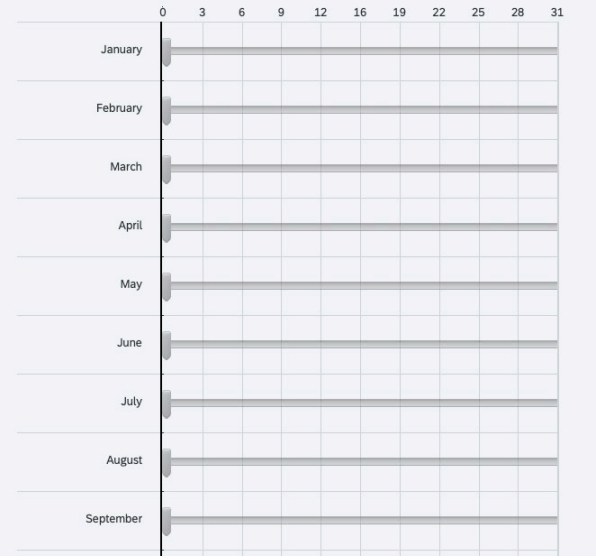
Section 1: General Shooting Practices

1. How often do you participate in the following types of recreational shooting?

Activity	**Never**	**Every two or more years**	**Once or twice a year**	**Once or twice a month**	**Once or twice a week**	**Nearly every day**
Shooting targets at an indoor range						
Shooting targets at an outdoor range						
Shooting targets outdoors **not** at a range						
Shooting ground squirrels/ “whistle pigs” and other varmint species						
Sighting in rifle for hunting season						
Target practice for hunting season						
Other (write in) _____						

2. How many years have you been recreational shooting? _____

3. About how many days do you typically go shooting during each month? Click on the line or drag the slider to choose a number. *Asked using sliders that go from 0 – 31 (photo of Qualtrics question below)*.



4. During which days of the week do you typically go shooting? Check all that apply.
   - ☐ Monday
   - ☐ Tuesday
   - ☐ Wednesday
   - ☐ Thursday
   - ☐ Friday
   - ☐ Saturday
   - ☐ Sunday

5. Answer the following questions for a typical shooting day:
   a. About how many hours do you spend shooting?
      - ☐ Less than 1 hour
      - ☐ 1- 2 hours
      - ☐ 2-3 hours
      - ☐ 3-4 hours
      - ☐ 4 or more hours

   b. About how many minutes do you spend driving to your shooting site?
      - ☐ Less than 15 minutes

□ 16- 30 minutes
□ 30-45 minutes
□ 1 hour
□ Over 1 hour

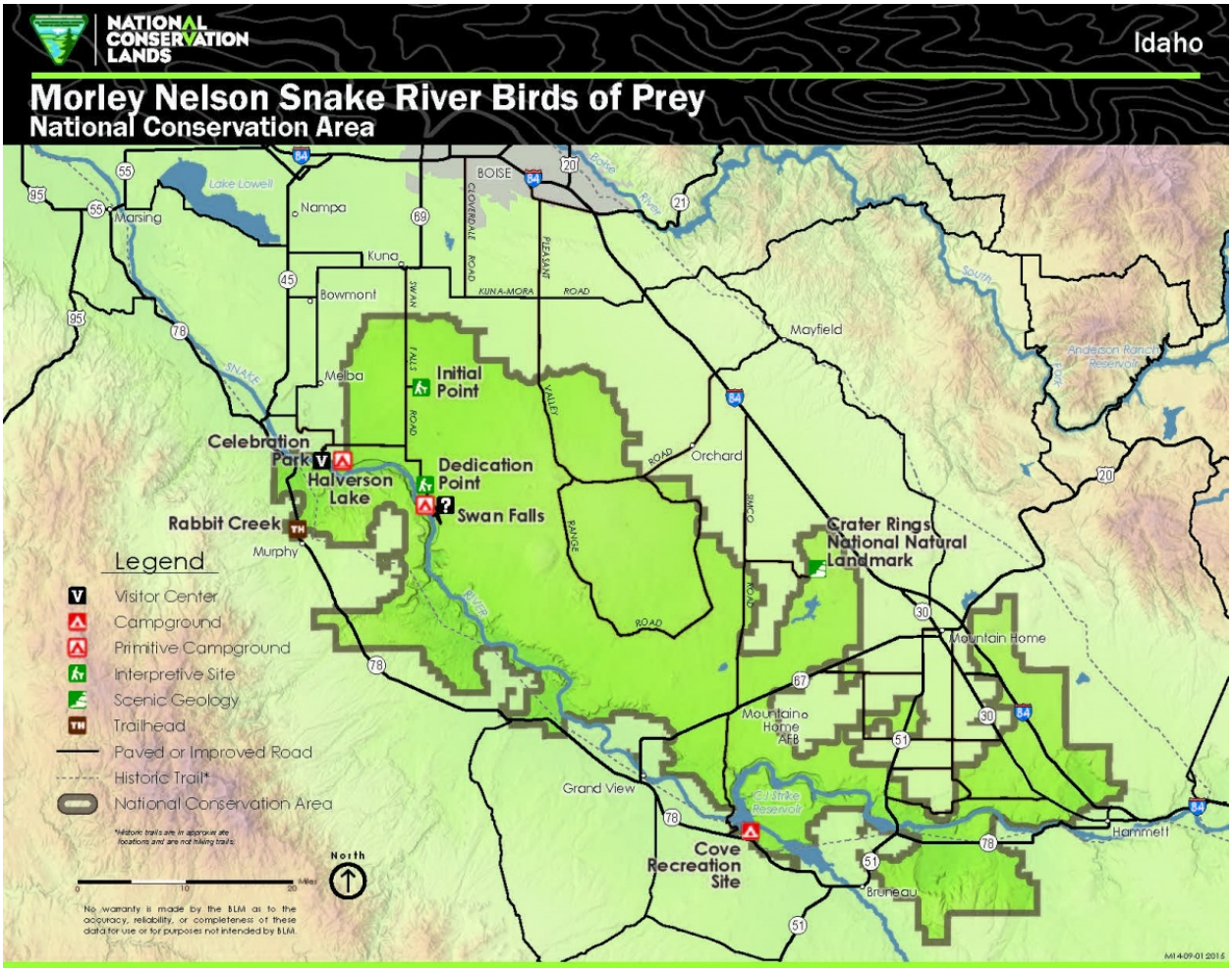
c. If applicable, about how many ground squirrels/Whistle Pigs do you shoot on a typical shooting day? _____

6. There are many reasons why someone might go recreational shooting. Several of these reasons are listed below. Please indicate how important each of these reasons is in influencing you to go recreational shooting. *Order of options is randomized.*

	Not at all important	**Moderately important**	**Very important**
Enjoying nature			
Experiencing solitude			
Spending time with friends or family			
Challenging yourself			
Testing your skills			
Getting exercise			
Viewing wildlife			
Having fun			
Practicing your skills			
Other (write in)			

Section 2: Shooting at the NCA

The Morley Nelson Snake River Birds of Prey National Conservation Area (NCA, Pleasant Valley, Swan Falls) is located south of Boise. A map of the area is shown below (map from https://www.blm.gov/programs/national-conservation-lands/idaho/morley-nelson-snake-river-birds-of-prey). The area within the boundary will be referred to as the NCA in the remaining questions.



1. How frequently do you go shooting at NCA?
   - ☐ Nearly every day
   - ☐ Once or twice a week
   - ☐ Once or twice a month
   - ☐ Once or twice a year
   - ☐ Once every two or more years
   - ☐ Never → *skip next question*

2. What types of shooting do you participate in at the NCA? Check all that apply. *Options are randomized.*
   - ☐ Shooting targets (i.e., not live animals)
   - ☐ Shooting ground squirrels/whistle pigs
   - ☐ Shooting other live targets
     Please specify_____
   - ☐ Sighting in rifle
   - ☐ Other _____ **always last* *

3. Do you participate in other recreational activities at the NCA? Check all that apply. *Options are randomized.*
    - ☐ None **always first**
    - ☐ Off-highway vehicle use
    - ☐ Biking
    - ☐ Hiking
    - ☐ Bird watching
    - ☐ Boating
    - ☐ Fishing
    - ☐ Climbing
    - ☐ Other_____ **always last**

Section 3: Site Selection

1. Within a shooting location (e.g. the NCA), what is important to you when selecting a site for recreational shooting? Click and drag the options to rank them from 1 (most important) to 5 (least important). *Options randomized.*
   - □ Vegetation type
   - □ Vantage points
   - □ Natural backstops
   - □ Ground squirrels/whistle pigs
   - □ Presence of other recreationists

2. For each of the following factors, choose how suitable a site with that characteristic would be. *Options randomized*.

	Not suitable	**Low suitability**	**Moderate suitability**	**High suitability**
Shrubs (e.g., sagebrush)				
Open (bare ground, low vegetation)				
Burned				
Rocky				
Near other shooting groups				
Far from other shooting groups				

3. Which venue do you prefer to shoot in? Click and drag the options to rank them from 1 (most preferred) to 5 (least preferred). *Options randomized.*
   - □ Indoor shooting range
   - □ Outdoor shooting range in town
   - □ Outdoor shooting range out of town
   - □ Outdoors on public land (e.g., BLM land)
   - □ Outdoors on private land

4. Which of the following best describes you? *Options randomized.*
   - □ I have a favorite shooting spot that I always use.
   - □ I have several shooting sites that I use.
   - □ I use the closest site that is open.

5. What prevents you from shooting at your preferred site(s)? **Check all that apply.** *Options randomized.*
   - □ Time
   - □ Ability to access sites
   - □ People already using your preferred site
   - □ Other groups using sites near your preferred site (being crowded)
   - □ Other _____ **always last**

Section 4: Limits of Acceptable Impacts

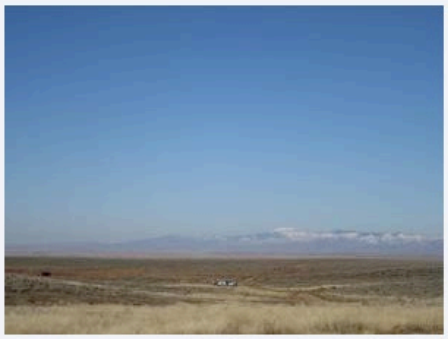
1. Rate the acceptability of each of the following sites for recreational shooting. Click on a photo to view at full size. *Order of pictures is randomized.*

Rate the acceptability of the following shooting sites.

	Very unacceptable	Somewhat acceptable	Neither	Somewhat acceptable	Very acceptable
	○	○	○	○	○
	○	○	○	○	○
	○	○	○	○	○

2. Rate the acceptability of each of the following sites for recreational shooting. Click on a photo to view at full size. *Order of pictures is randomized.*

Rate the acceptability of the following sites for recreational shooting . Click on a photo to view at full size.

	Very unacceptable	Somewhat unacceptable	Neither	Somewhat acceptable	Very acceptable
	○	○	○	○	○
	○	○	○	○	○
	○	○	○	○	○

Section 5: Demographic Information

1. Where is your current residence?
   - ☐ Idaho: which county? _____
   - ☐ Another state: which state? _____
   - ☐ Another country: which country? _____

2. How many years have you lived in the Treasure Valley or surrounding area? _____

3. What year were you born? _____

4. What is your gender?
   - ☐ Male
   - ☐ Female

5. What is the highest level of education that you have completed?
   - ☐ Less than high school diploma
   - ☐ High school diploma/GED
   - ☐ Some college/ 2-year degree
   - ☐ 4-year degree
   - ☐ Graduate degree

6. What is your occupation? _____

7. How many people are in your household?
   - ☐ 1
   - ☐ 2
   - ☐ 3
   - ☐ 4
   - ☐ 5
   - ☐ 6 or more

8. What is your annual household income before taxes?
   - ☐ Less than $10,000
   - ☐ $10,000-$19,999
   - ☐ $20,000-$29,999
   - ☐ $30,000-$39,999

☐ $40,000-$49,999
☐ $50,000-$59,999
☐ $60,000-$69,999
☐ $70,000-$79,999
☐ $80,000-$89,999
☐ $90,000-$99,999
☐ $100,000-$149,999
☐ More than $150,000

Section 6: Rules & Regulations

1. How many of the following species have you shot while in southern Idaho? **Check one of the answer options to indicate the number that apply.**
   *** Randomly assigned treatment or baseline****


Ground squirrels


Badgers


Coyotes


Jack rabbits


Long-billed Curlew

*** treatment group only****

☐ 0
☐ 1
☐ 2
☐ 3
☐ 4
☐ 5 *** treatment group only****

2. Have you attended a Hunter Education course?
   ☐ Yes
   ☐ No

3. Which of the following species are legal to shoot **year-round without a permit or tag** in Idaho? Check all that apply. *Options randomized.*
   ☐ Piute ground squirrels (whistle pigs) in western Idaho
   ☐ Coyotes
   ☐ Birds of prey (eagles, hawks, falcons)
   ☐ Badgers
   ☐ Jackrabbits
   ☐ Rattlesnakes
   ☐ Native songbirds (robins, chickadees, etc.)
   ☐ Non-native songbirds (starlings, Eurasian collar doves)
   ☐ Corvids (crows, ravens, magpies)

4. Where do you get your information about shooting rules and regulations? _____

5. How important is it to you to follow rules and regulations while shooting?
   - □ Vey unimportant
   - □ Somewhat unimportant
   - □ Not important
   - □ Somewhat important
   - □ Very important

6. How likely would you be to report someone you saw breaking a law while shooing?
   - □ Very unlikely
   - □ Somewhat unlikely
   - □ Not likely
   - □ Somewhat likely
   - □ Very likely

7. Indicate your agreement with the following statements. *Options randomized.*

	Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
Each individual who goes shooting is responsible for making sure they are following the rules.							
Shooters who use a site are responsible for making sure everyone is following the rules							
Shooting interest groups (e.g., The Idaho Varmint Hunters, Inc.) are responsible for making sure all shooters the rules							

Other recreationists at a site are responsible for making sure all shooters follow the rules							
Law enforcement officials responsible for making sure all shooters follow the rules							
Management agencies (BLM, USFWS) are responsible for making sure all shooters follow the rules							

8. Which of the following would most help to increase the number of people following rules and regulations? *Options randomized*
   - □ No change necessary **always first**
   - □ Public education
   - □ Management changes
   - □ Recreationist participation
   - □ Limiting the number of people who can use a site
   - □ Other _____ **always last**

Is there anything else you want me to know about why you shoot recreationally? (*open-ended*)

APPENDIX F: ONLINE SURVEY MATERIALS – OUTDOOR RECREATION IN THE TREASURE VALLEY

The purpose of this survey is to learn about the experiences, preferences, and concerns of outdoor recreationists in the Treasure Valley. You are being asked to take this survey to share your experiences with outdoor recreation. Your responses will help to better inform management agencies about the priorities of recreationists in the Treasure Valley.

Survey participation is voluntary. The survey will take approximately 10 minutes or less to complete.

You must be at least 18 years old to take this survey.

This study involves no foreseeable serious risks. The researchers will make every

effort to protect your confidentiality. However, the researchers are requesting demographic information. Due to the make-up of Idaho's population, the combined answers to these questions may make an individual person identifiable.

We ask that you try to answer all questions; however, you may choose to skip any question you do not wish to answer. You are free to stop the survey and clear your responses at any time.

Your confidentiality will be maintained to the degree permitted by the technology used. Specifically, no guarantees can be made regarding the interception of data sent via the Internet by any third parties. We will protect your confidentiality and anonymity by transferring and storing responses in an encrypted form. We will not store your IP address or other identifiable data with your survey response. In reports and publications, responses will be displayed in aggregate form.

If you have any questions or concerns, feel free to contact Madeline or her faculty advisor:

Madeline Aberg, graduate student
Biological Sciences
(641) 590-5554
madelineaberg@boisestate.edu

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Biological Sciences
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jaycarlisle@boisestate.edu

If you have questions about your rights as a research participant, you may contact the Boise State University Institutional Review Board, which is concerned with the protection of volunteers in research projects and has reviewed and approved this survey. The IRB protocol number is 001-SB19-045. You may reach the board office between 8:00 AM and 5:00 PM, Monday through Friday, by calling (208) 426-5401 or by writing: Institutional Review Board, Office of Research Compliance, Boise State University, 1910 University Dr., Boise, ID 83725-1138.

Do you consent to participating in this survey?

Answer options (must respond to proceed):

Yes, I consent → *begin survey*

No, I do not consent → *end survey*

Section 1: General Practices

1. How often do you participate in the following types of outdoor recreational activities?

Activity	**Never**	**Every two or more years**	**Once or twice a year**	**Once or twice a month**	**Once or twice a week**	**Nearly every day**
Shooting targets at an outdoor range						
Shooting targets outdoors **not** at a range						
Shooting ground squirrels/ "whistle pigs" and other varmint species						
Birdwatching						

Motorized recreation (OHV, dirt bikes, etc.)						
Hiking						
Rock climbing						
Fishing						
Water sports (boating, kayaking, etc.)						
Other: _____						

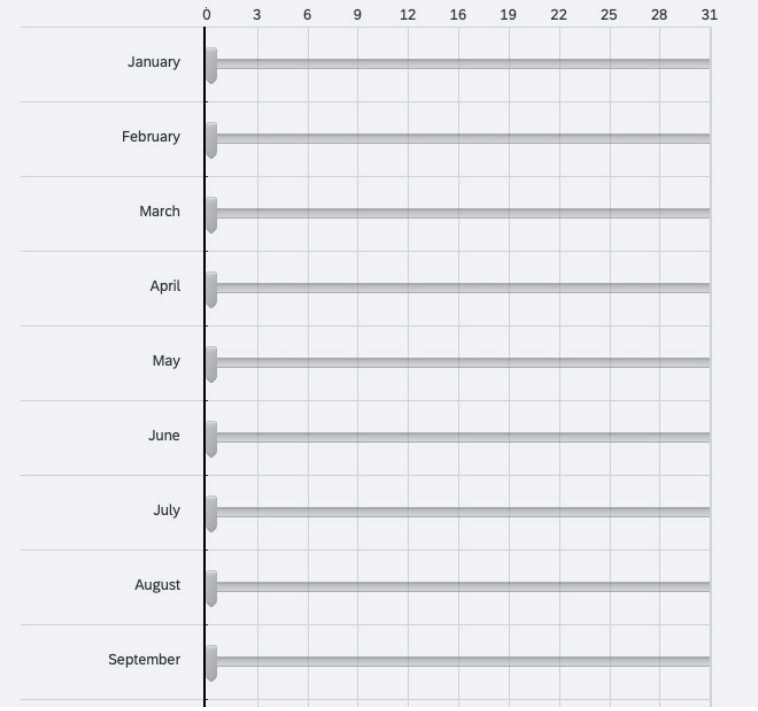
2. Choose the activity you participate in the most frequently while recreating outdoors in southwestern Idaho:

- □ Shooting targets
- □ Shooting ground squirrels or other varmint species
- □ Birdwatching
- □ Motorized recreation
- □ Hiking
- □ Rock climbing
- □ Fishing
- □ Water sports
- □ Other _____

Use the activity you chose to answer the following questions.

3. How many years have you been participating in this activity? _____

4. About how many days do you typically do this activity each month? Click on the line or drag the slider to choose a number. *Asked using sliders that go from 0 – 31 (photo of Qualtrics question below)*.



5. During which days of the week do you typically do this activity? Check all that apply.

- ☐ Monday
- ☐ Tuesday
- ☐ Wednesday
- ☐ Thursday
- ☐ Friday
- ☐ Saturday
- ☐ Sunday

6. Answer the following questions for a typical day recreating:

a. About how many hours do you spend?

- ☐ Less than 1 hour
- ☐ 1- 2 hours
- ☐ 2-3 hours
- ☐ 3-4 hours
- ☐ 4 or more hours

b. About how many minutes do you spend driving to your site?

- ☐ Less than 15 minutes
- ☐ 16- 30 minutes
- ☐ 30-45 minutes

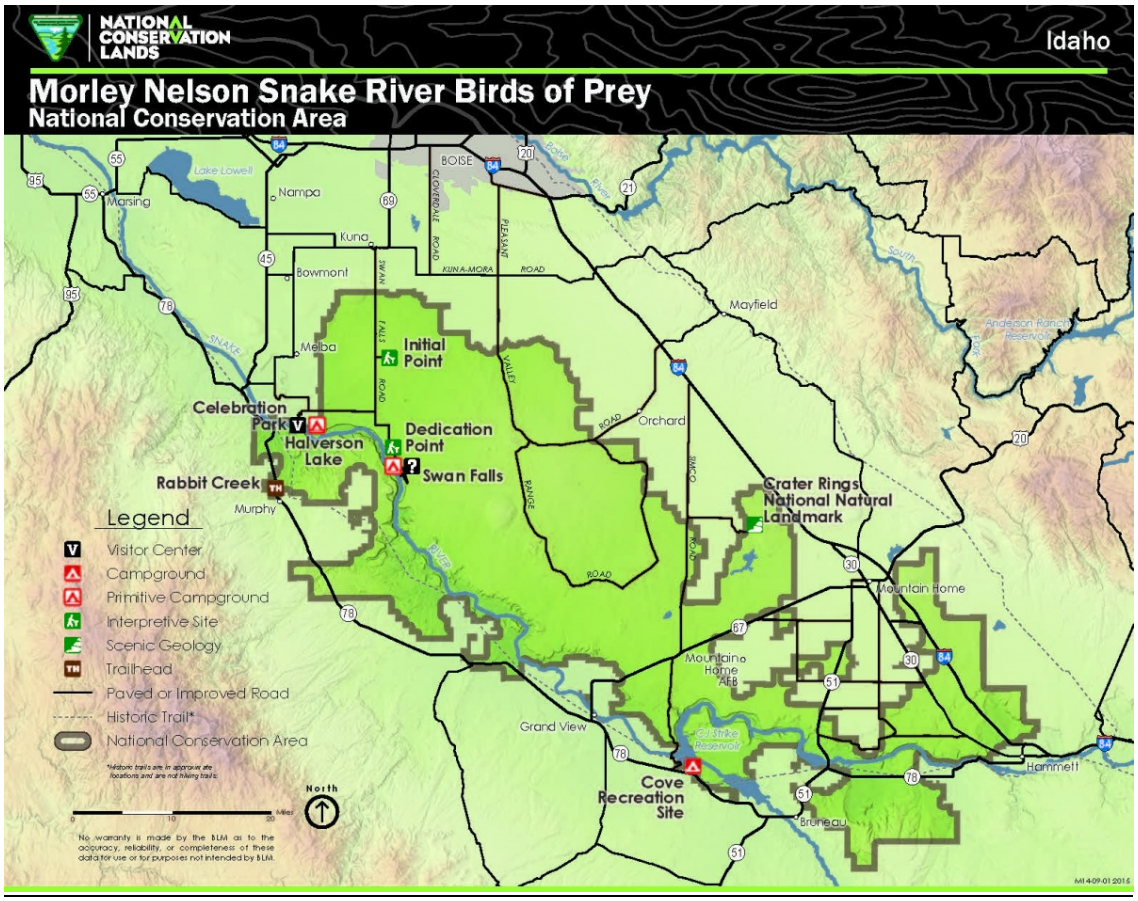
□ 1 hour
□ Over 1 hour

7. There are many reasons why someone might participate in outdoor recreation. Several of these reasons are listed below. Please indicate how important each of these reasons is in influencing you to recreate. *Order of options is randomized.*

	Not at all important	**Slightly important**	**Somewhat important**	**Important**	**Very important**
Enjoying nature					
Experiencing solitude					
Spending time with friends or family					
Challenging yourself					
Testing your skills					
Getting exercise					
Viewing wildlife					
Having fun					
Practicing your skills					
Other (write in)					

Section 2: Recreating at the NCA

The Morley Nelson Snake River Birds of Prey National Conservation Area (NCA, Pleasant Valley, Swan Falls) is located south of Boise. A map of the area is shown below (map from https://www.blm.gov/programs/national-conservation-lands/idaho/morley-nelson-snake-river-birds-of-prey). The area within the boundary will be referred to as the NCA in the remaining questions.



1. How frequently do you go recreating at NCA?
   - ☐ Nearly every day
   - ☐ Once or twice a week
   - ☐ Once or twice a month
   - ☐ Once or twice a year
   - ☐ Once every two or more years
   - ☐ Never → *skip next question*

2. What types of outdoor recreational activities do you participate in at the NCA? Check all that apply. *Options are randomized.*
   - ☐ None **always first**
   - ☐ Shooting targets (i.e., not live animals)
   - ☐ Shooting ground squirrels/whistle pigs
   - ☐ Shooting other live targets
     Please specify_____
   - ☐ Sighting in rifle
   - ☐ Shooting targets
   - ☐ Shooting ground squirrels or other varmint species
   - ☐ Birdwatching

□ Motorized recreation
□ Hiking
□ Rock climbing
□ Fishing
□ Water sports
□ Other_____ **always last**

Section 3: Site Selection

1. Which of the following best describes you? *Options randomized.*
□ I have a favorite spot that I always use when I go recreating.
□ I have several sites that I use.
□ I use the closest site that is open.

2. What prevents you from recreating at your preferred site(s)? **Check all that apply.** *Options randomized.*
□ Time
□ Ability to access sites
□ People already using your preferred site
□ Other groups using sites near your preferred site (being crowded)
□ Other _____ **always last**

Section 4: Limits of Acceptable Impacts

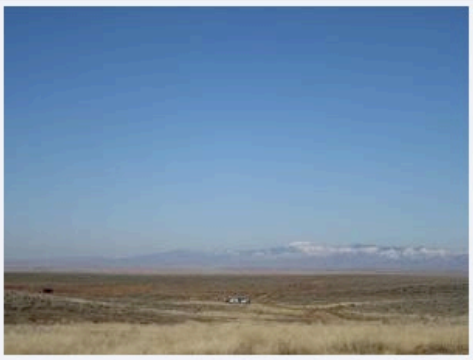
1. Rate the acceptability of each of the following sites for your outdoor recreational activity. Click on a photo to view at full size. *Order of pictures is randomized.*

Rate the acceptability of the following shooting sites.

	Very unacceptable	Somewhat acceptable	Neither	Somewhat acceptable	Very acceptable
	○	○	○	○	○
	○	○	○	○	○
	○	○	○	○	○

2. Rate the acceptability of each of the following sites for your outdoor recreational activity. Click on a photo to view at full size. *Order of pictures is randomized.*

Rate the acceptability of the following sites for recreational shooting . Click on a photo to view at full size.

	Very unacceptable	Somewhat unacceptable	Neither	Somewhat acceptable	Very acceptable
	○	○	○	○	○
	○	○	○	○	○
	○	○	○	○	○

Section 5: Demographic Information

1. Where is your current residence?

☐ Idaho: which county? _____
☐ Another state: which state? _____
☐ Another country: which country? _____

2. How many years have you lived in the Treasure Valley or surrounding area? _

3. What year were you born? _____

4. What is your gender?
   - ☐ Male
   - ☐ Female

5. What is the highest level of education that you have completed?

☐ Less than high school diploma
☐ High school diploma/GED
☐ Some college/ 2-year degree
☐ 4-year degree
☐ Graduate degree

6. What is your occupation? _____
7. How many people are in your household?
   - ☐ 1
   - ☐ 2
   - ☐ 3
   - ☐ 4
   - ☐ 5
   - ☐ 6 or more

8. What is your annual household income before taxes?
   - ☐ Less than $10,000
   - ☐ $10,000-$19,999
   - ☐ $20,000-$29,999
   - ☐ $30,000-$39,999
   - ☐ $40,000-$49,999
   - ☐ $50,000-$59,999

☐ $60,000-$69,999
☐ $70,000-$79,999
☐ $80,000-$89,999
☐ $90,000-$99,999
☐ $100,000-$149,999
☐ More than $150,000

Section 6: Rules & Regulations

1. Where do you get your information about rules and regulations for outdoor recreation? _____

2. How important is it to you to follow rules and regulations while recreating?
   - Vey unimportant
   - Somewhat unimportant
   - Not important
   - Somewhat important
   - Very important

3. How likely would you be to report someone you saw breaking a law while recreating?
   - Very unlikely
   - Somewhat unlikely
   - Not likely
   - Somewhat likely
   - Very likely

4. Indicate your agreement with the following statements. *Options randomized.*

	Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
Each individual who goes recreating is responsible for making sure they are following the rules.							

Recreation interest groups are responsible for making sure all recreationists follow the rules							
Other recreationists at a site are responsible for making sure all recreationists follow the rules							
Law enforcement officials responsible for making sure all recreationists follow the rules							
Management agencies (BLM, USFWS) are responsible for making sure all recreationists follow the rules							

5. Which of the following would most help to increase the number of people following rules and regulations? *Options randomized*

□ No change necessary **always first**
□ Public education
□ Management changes
□ Recreationist participation
□ Limiting the number of people who can use a site
□ Other _____ **always last**

Is there anything else you want me to know about why you participate in outdoor recreation? (*open-ended*)

APPENDIX G: ON-SITE SEMI-STRUCTURED RECREATION INTERVIEW SCRIPT AND QUESTIONS

Investigator will recruit participants following the Recruitment Script (On-site Survey Recruitment Script.doc) and give the participant the cover letter (Cover-Letter-for-Anonymous-On-Site-Surveys.doc) to gain consent before beginning the interview.

During the interview, the investigator will read the questions and fill out with the participant's responses. The investigator will also record notes of any additional details or comments from the participant.

All investigator instructions are italicized. All non-italicized writing will be read aloud to the participant. Headings (bold and underlined) are for investigator organization and will not be read aloud. A random number table will be used to randomize the order of options where noted.

Introduction

Thank you for agreeing to speak with me today. The purpose of this survey is to learn about recreational shooting practices in the Treasure Valley. You are being asked to take this survey to share your experiences with recreational shooting. Your responses will help to better inform management agencies about the priorities of recreational shooters.

Throughout the interview, I will use the term "recreational shooting" is used to refer to a variety of activities, including:

- Shooting "varmint" species (ground squirrels/"whistle pigs," marmots/"rock chucks," coyotes, badgers)
- Shooting targets
- Sighting-in rifle
- Shooting clay pigeons

General Shooting Practices

1. How often do you participate in the following types of recreational shooting?

Activity	Never	Every two or more years	Once or twice a year	Once or twice a month	Once or twice a week	Nearly every day
Shooting targets at an indoor range						
Shooting targets at an outdoor range						
Shooting targets outdoors **not** at a range						
Shooting ground squirrels/ "whistle pigs" and other varmint species						
Sighting in rifle for hunting season						
Target practice for hunting season						
Other _____						

2. How many years have you been recreational shooting? _____

3. How did you get started shooting? *Open-ended*

4. About how many days do you typically go shooting during each month?
   January _____
   February _____
   March _____
   April _____
   May _____
   June _____
   July _____
   August _____
   September _____
   October _____
   November _____
   December _____

5. During which days of the week do you typically go shooting? *Check all that apply*

- □ Monday
- □ Tuesday
- □ Wednesday
- □ Thursday
- □ Friday
- □ Saturday
- □ Sunday

6. Describe a typical shooting day (open-ended):

If they don't mention it, ask:

i. About how many hours do you spend shooting?

ii. About how many minutes do you spend driving to your shooting site?

iii. If applicable, about how many ground squirrels/Whistle Pigs do you shoot?

7. There are many reasons why someone might go recreational shooting. Several of these reasons are listed below. Please indicate how important each of these reasons is in influencing you to go recreational shooting. *Give participants a chance to elaborate on the reasons. Change the order of options each time using the random number table.*

	Not at all important	**Slightly important**	**Moderately important**	**Important**	**Extremely important**
1) Enjoying nature					
2) Experiencing solitude					
3) Spending time with friends or family					
4) Challenging yourself					
5) Testing your skills					
6) Getting exercise					
7) Viewing wildlife					
8) Having fun					
9) Practicing your skills					

Are there other reasons that weren't mentioned?

Site Selection

1. Within a shooting location (e.g., the NCA), what is important to you when selecting a site for recreational shooting? Rank the following factors from 1 (most important) to 5 (least important). *Change the order of options each time using the random number table.*

- □ Vegetation type (1)
- □ Vantage points (2)
- □ Natural backstops (3)
- □ Number of ground squirrels (4)
- □ Presence of other recreationists (5)

2. Are there any other factors that were not listed that are important to you? *Open-ended.*

3. What type of venue do you like to shoot in? Rank the following from 1 (most preferred) to 5 (least preferred). *Change the order of options each time using the random number table.*

- □ Indoor shooting range (1)
- □ Outdoor shooting range in town (2)
- □ Outdoor shooting range out of town (3)
- □ Outdoors on public land (e.g., BLM land) (4)
- □ Outdoors on private land (5)

4. Why do you prefer *(fill in answer to question 3)* over the others?

5. What prevents you from shooting at your preferred site(s)? *Check all that apply*.

- □ Time
- □ Ability to access sites
- □ People already using your preferred site
- □ Other groups using sites near your preferred site (being crowded)
- □ Other

Limits of Acceptable Impacts

1. *Show the photos of varying trash conditions in a random order.* Please rate each site as very unacceptable- unacceptable – neutral – acceptable – very acceptable.

high: very unacceptable- unacceptable – neutral – acceptable – very acceptable

medium: very unacceptable- unacceptable – neutral – acceptable – very acceptable

low: very unacceptable- unacceptable – neutral – acceptable – very acceptable

2. *Show the photos of varying trash conditions in a random order.* Please rate each site as very unacceptable- unacceptable – neutral – acceptable – very acceptable

Low: very unacceptable- unacceptable – neutral – acceptable – very acceptable

Medium: very unacceptable- unacceptable – neutral – acceptable – very acceptable

High: very unacceptable- unacceptable – neutral – acceptable – very acceptable

3. What would make you stop visiting one of your favorite sites? (*open-ended*)

If mentions behaviors:

i. What do you see?
ii. How prevalent?
iii. How does this affect your experience?

Demographics

1. Where is your current residence?

☐ Idaho: which county? _____
☐ Another state: which state? _____
☐ Another country: which country? _____

2. How many years have you lived in the Treasure Valley? _____

3. What year were you born? _____

4. What is the highest level of education that you have completed?

☐ Less than high school diploma
☐ High school diploma/GED
☐ Some college
☐ Two-year degree
☐ Four-year degree
☐ Professional degree

☐ Doctorate

Is there anything else you want me to know about why you shoot recreationally? (*open-ended*)

APPENDIX H: SEMI-STRUCTURED INTERVIEW SCRIPT AND QUESTIONS FOR MANAGERS AND BIOLOGISTS

Investigator will recruit participants via email (Management-Recruitment-Email.doc) and give the participant the cover letter (Cover-Letter-for-Management-Surveys.doc) to gain consent before beginning the interview.

During the interview, the investigator will read the questions and fill out with the participant's responses. The investigator will also record notes of any additional details or comments from the participant.

All investigator instructions are italicized. All non-italicized writing will be read aloud to the participant. Headings (bold and underlined) are for investigator organization and will not be read aloud. A random number table will be used to randomize the order of options where noted.

Introduction

Thank you for agreeing to speak with me today.

The purpose of this survey is to learn about recreational management practices in the Treasure Valley, with a focus on recreational shooting. You are being asked to take this survey to share your experiences.

Throughout the interview, I will use the term "recreational shooting" is used to refer to a variety of activities, including:

- Shooting "varmint" species (ground squirrels, marmots, coyotes, badgers)
- Shooting targets
- Sighting-in rifle
- Shooting clay pigeons

This study involves no foreseeable serious risks. We will make every effort to protect your confidentiality. We ask that you try to answer all questions; however, you may skip any questions for any reason. Your responses are anonymous.

We may use direct quotes from this interview in reports or publications. All quotes will be reported anonymously without demographics or other information that could identify the source of the quote. The name of your agency may be included in the report but will not be associated with your answers.

General

1. How long have you been working with [management agency]? _____

2. What area of management are you/your agency focused on? *Open-ended*

Perceptions of Recreation Trends *Only asked of managers who had worked at the site for multiple years and spend time at the NCA regularly.*

1. During which months is recreational use at the NCA the busiest?

January _____
February _____
March _____
April _____
May _____
June _____
July _____
August _____
September _____
October _____
November _____
December _____

2. During which months is recreational use at the NCA the slowest?
January _____
February _____
March _____
April _____
May _____
June _____
July _____
August _____
September _____
October _____
November _____
December _____

3. During which days of the week do you see the most recreationists/recreational shooters? *Check all that apply*
□ Monday
□ Tuesday
□ Wednesday
□ Thursday
□ Friday
□ Saturday
□ Sunday

4. There are many reasons why someone might go recreational shooting. Several of these reasons are listed below. Please indicate how important you perceive each of these reasons is in influencing people who go recreational shooting. *Give participants a chance to elaborate on the reasons. Change the order of options each time using the random number table.*

	Not at all important	**Slightly important**	**Moderately important**	**Very important**	**Extremely important**
1) Enjoying nature					
2) Experiencing solitude					
3) Spending time with friends or family					
4) Challenging themselves					
5) Testing their skills					
6) Getting exercise					
7) Viewing wildlife					
8) Having fun					
9) Practicing their skills					

Are there other reasons that weren't mentioned?

Site Selection *Only asked of managers who had worked at the site for multiple years and spend time at the NCA regularly.*

1. What factors do you perceive as being important to people who are selecting a site for recreational shooting? Rank the following factors from 1 (most important) to 5 (least important). *Change the order of options each time using the random number table.*
   - □ Vegetation type (1)
   - □ Vantage points (2)
   - □ Natural backstops (3)
   - □ Number of ground squirrels (4)
   - □ Presence of other recreationists (5)

2. Are there any other factors that were not listed that you think are important? *Open-ended.*

3. What do you think prevents recreationists from shooting at their preferred site(s)? *Check all that apply.*
   - □ Time
   - □ Ability to access sites
   - □ People already using their preferred site
   - □ Other groups using sites near their preferred site (being crowded)
   - □ Other _____

Limits of Acceptable Impacts

1. Show the photos of varying trash conditions in a random order. Please rate each site as very unacceptable- unacceptable – neutral – acceptable – very acceptable.

High:


Medium:


Low:

2. *Show the photos of varying trash conditions in a random order.* Please rate each site as very unacceptable- unacceptable – neutral – acceptable – very acceptable


Low:


Medium:


High:

3. What concerns do you have about the impact of recreation in protected areas? (*open-ended*)

If mentions behaviors:

iv. What do you see?
v. How prevalent?
vi. How does this affect your experience?

4. Have you noticed impacts to the site that change the behaviors of other recreationists?

5. Do you notice any conflicts between recreationists who use these sites?

Section 6: Rules & Regulations

1. Do you have concerns about recreational shooters not following rules and regulations while recreating on Idaho public lands?

2. Do you think recreational shooters know which species can be legally shot year-round without a permit or tag?

    i. Are there species or groups of species that you have concerns about being shot illegally?

3. Where do you think most recreational shooters get their information about shooting rules and regulations?

4. What would be the best places for recreationists to get information about rules and regulations?

5. Are there management actions that you think would be helpful? *Open-ended*

Is there anything else you want me to know about recreational shooting or management?

(*open-ended*)