THESIS

EFFECTS OF BIRDWATCHERS ON SANDHILL CRANE (GRUS CANADENSIS) BEHAVIOR AT SPRING STOPOVER SITES IN THE SAN LUIS VALLEY, COLORADO

Submitted by

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ABSTRACT

EFFECTS OF BIRDWATCHERS ON SANDHILL CRANE (GRUS CANADENSIS) BEHAVIOR AT SPRING STOPOVER SITES IN THE SAN LUIS VALLEY, COLORADO

Human recreational activities can disturb wildlife by causing animals to alter feeding patterns, or change feeding locations. Migratory birds in particular can be susceptible to disturbance since they have limited time for resting, feeding and courtship along their migratory routes. Sandhill cranes (*Grus canadensis*) are an iconic and charismatic species that stop in Colorado's San Luis Valley during each spring and fall migration, which has led to an annual spring bird watching festival at the Monte Vista National Wildlife Refuge. The goal of this research was to understand how birdwatchers drawn by the festival affect the behavior of sandhill cranes in this important migration stopover site. For the purposes of this research, "birdwatchers" are defined as any person present in the pullouts where we conducted observations of crane behavior.

The behavior of sandhill cranes was observed using focal animal sampling techniques during March 2010 and 2011 at sites both on and off the Monte Vista National Wildlife Refuge. The number of birdwatchers at a particular site did not affect the time cranes spent in vigilance postures; however, cranes spent more time vigilant on the Monte Vista National Wildlife Refuge than on privately owned lands, where there were fewer observers. Overall, the results of this study suggest that the birdwatchers during the festival had minimal impact on sandhill crane behavior on the refuge, including open lands managed as agricultural fields. The results of this research can inform adaptive management approaches to balance bird watching opportunities and the needs of charismatic migratory species.

ACKNOWLEDGEMENTS

The completion of my master's thesis project would not have been possible without the help of many people. Thanks to my advisors, Dr. John Moore and Dr. Gillian Bowser, as well as committee members Lisa Angeloni and Liba Pejchar, for their support and insight throughout this project. I would also like to thank the Alliance for Graduate Education and the Professoriate, as well as the U.S. Department of Agriculture's National Needs Fellowship for providing me with the funding to pursue a Master's in Ecology. Many thanks to various people within Colorado State University's Graduate Degree Program in Ecology and the Natural Resource Ecology Lab for your support. I especially thank my family and friends for their constant guidance and words of encouragement!

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1. INTRODUCTION

Migrating birds can be susceptible to human disturbance along migratory routes, especially at stopover areas where they have a short amount of time to feed, rest, and engage in courtship activities before continuing their migration (Newton 2006; Skagen 2006). The potential for human disturbance of migratory birds can be problematic for wildlife preserves and refuges that promote bird watching events, such as the crane festival in Colorado or the popular Texas birding trails, as they also have the responsibility to conserve migratory bird populations (Carney & Sydeman 1999; Sekercioḡ lu 2002). There are over 200 of these events in the U.S. and Canada (Scott *et al.* 2003), and birdwatchers in general can have significant economic impacts to the areas they visit (Kim *et al.* 1998; Case & Sanders 2009; Carver 2009). Festivals can positively affect local economies, as well as protected areas, by increasing conservation awareness amongst the public (Sekercioḡ lu 2002); however, birdwatchers may also impact the same migratory bird species the refuges are trying to protect.

The impacts of bird watching and other recreation activities on migratory species have been demonstrated for some species. Previous studies on water birds and shorebirds found that human activities negatively impacted foraging (Burger 1994; Burger & Gochfeld 2001; Wang *et al.* 2010), distribution (Burger 1994), abundance (Pfister *et al.* 1992) and breeding success (Madsen 1994; Verhust *et al.* 2001). A primary concern is the potential for human activity to alter behavior in a way that decreases individual fitness, which in turn can lead to population declines (Liley & Sutherland 2007). The risk-disturbance hypothesis postulates that birds and other wildlife species perceive human disturbance as a form of predation risk (Frid & Dill 2002). Under this hypothesis, human disturbance could elicit behavioral responses that lead to declines in individual fitness by impairing their ability to feed, select mates and breed successfully (Frid

& Dill 2002). How birds react to human disturbances can depend on the number of people (Burger 1994; Yasue 2005), frequency of the interaction with the disturbance stimuli (Rodriguez-Prieto *et al.* 2008), proximity to people (Burger & Gochfeld 1991; Burger & Gochfeld 2001), as well as flock size (Lima 1995; Roberts 1996; Wang *et al.* 2010) and time of day (Thomas *et al.* 2003). Birds may also face the opposite direction or move away from a perceived disturbance (Burger & Gochfeld 1991). Shifting their location or position could potentially place them in less optimal foraging habitats (Gill 2007). In response to human disturbance, birds may increase vigilance, or time spent scanning for "predators" and with the additional time spent being vigilant, they may devote less time to foraging activities (Burger 1994; Thomas *et al.* 2003; Yasue 2005). Research on harbor seals (Terhune 1996) and white-tailed deer (Lingle & Wilson 2001) demonstrated that these animals oriented the front of their body away from potential disturbances to facilitate a faster escape from potential predators. While some bird species may visibly respond when exposed to people, for example by increasing vigilance, others may exhibit varying levels of tolerance (Fernández-Juricic *et al.* 2001). Some species even become habituated to these interactions (Rodriguez-Prieto *et al.* 2008) with decreased responsiveness over time to repeated exposure to disturbances that are neither harmful nor beneficial (Bejder *et al.* 2009).

Migratory bird festivals have the potential to increase conservation efforts by making the public more aware of certain species (Sekercioḡ lu 2002), but previous research has demonstrated that birdwatchers can disturb birds (Carney & Sydeman 1999; Sekercioḡ lu 2002; Wang *et al.* 2010). Red-crowned cranes on a reserve in China devoted less time to foraging and more time to vigilance with an increase in human observers (Wang *et al.* 2010). Burger and Gotchfield (2001) found that sandhill cranes increased vigilance in response to humans at distances of 70-300 meters away in the Colorado Platte River Valley (CPRV) of Nebraska, which has become a popular destination for birdwatchers. Around 90,000 people visit the CPRV each spring to witness the migration of over 500,000 sandhill cranes, while also contributing $30 million to the local economy (Case & Sanders 2009).

More than 20,000 birds stop at the Monte Vista National Wildlife Refuge and neighboring agricultural fields during the annual spring migration of sandhill cranes across North America (Kruse *et al.* 2012). Greater sandhill cranes (*Grus canadensis tabida*) from the Rocky Mountain population make up the majority of cranes that migrate to the valley in the spring (Kruse *et al.* 2012). However, in the past 20 years the mid-continental population, comprised of lesser (*Grus canadensis canadensis*) and greater sandhill cranes, also began arriving in the valley during the spring in small numbers (Kruse *et al.* 2012).

During the spring stopover, the valley hosts a crane festival that attracts around 10,000 birdwatchers to the Monte Vista National Wildlife Refuge (USFWS 2003). This research sought to understand how birdwatchers at the Monte Vista National Wildlife Refuge affected the time sandhill cranes devoted to vigilance, foraging and facing away from the visitor pullouts during their spring migration. I also recorded sandhill crane behavior at sites off the refuge that did not have visitor pullouts to determine whether crane behavior differed at sites with and without birdwatchers. In accordance with the risk-disturbance hypothesis, I predicted that as birdwatchers increased to the pullouts, sandhill cranes would spend less time feeding and devote more time to vigilance. Based on the research by Terhune (1996), as well as Lingle and Wilson (2001), I predicted that cranes would spend more time facing away from the source of disturbance (the pullouts) as the number of bird watchers at the pullouts increased. I also predicted that sandhill cranes would spend more time feeding, devote less time to vigilance and spend less time facing away from the source of disturbance (the road) at sites off the refuge that would have fewer interruptions due to visitation from birdwatchers compared to the sites on the refuge with established pullouts.

2. METHODS

2.1 Study Area

The Monte Vista National Wildlife Refuge was created by the Migratory Bird Conservation Commission in 1952 in response to declines in waterfowl winter habitat (USFWS 2011). The refuge actively manages for cranes and waterfowl by pumping 8,200 acre feet of groundwater and diverting 8,500 acre feet of water from the Rio Grande River to maintain both agricultural fields and alpine-montane wet meadows (hereafter, wet meadows) on the refuge property (USFWS 2003). The agricultural fields consist mainly of barley and alfalfa, while the wet meadows support grasses and forbs (USGS 2004). Refuge managers work with local farmers to create center-pivot agricultural fields on refuge lands, which are left fallow (uncut) after the harvest so cranes can feed on left over grains and invertebrates that are attracted to the uncut fields (Laubhan 2001). Local farmers also have agreements with the refuge to leave their own private fields off the refuge uncut for cranes (Haufler 2005).

The study included locations both on and off the Monte Vista National Wildlife Refuge in southwestern Colorado (Figure 1). Study sites included six fields on the refuge and six fields off the refuge (Figure 2). Sites on and off the refuge were chosen based on the presence of cranes that were noted while driving around the valley prior to initiating the study. Sites on the refuge were actively managed agricultural lands and alpine-montane wet meadows located within the boundary of the Monte Vista National Wildlife Refuge and had established pullouts for visitors to view cranes. On the refuge, we made observations at three fields classified as wet meadows that supported grasses and forbs, and three agricultural fields that grew barley and alfalfa (USGS 2004). Sites located off the Monte Vista National Wildlife Refuge property included five privately owned agricultural fields consisting of barley and alfalfa and one privately owned man-made pond, hereafter open water (USGS 2004). All sites off the refuge were adjacent to dirt and paved roads, and did not contain pullouts for crane viewing.

2.2 Focal Animal Sampling

Behavioral observations took place from March 15-18, 2010 and from March 6-13, 2011 during the height of the spring crane migration. The number of observers varied between 2010 (6) and 2011 (2), and all observers were trained in advance on the focal animal techniques. We observed cranes for one hour at 4 to 5 sites per day from 8 a.m. to 4 p.m. We sampled an equal number of sites on and off the Monte Vista National Wildlife Refuge each day. At each sampling event, temperature and wind speed information (Carr & Lima 2010) was recorded from the Alamosa weather station (www.wunderground.com), as well as time of day and vegetation in the field (agriculture, wet meadow or open water).

Focal observations of individual cranes (n = 491) were conducted with a spotting scope and lasted five minutes each (Altman 1974; Tacha 1987; Wang *et al.* 2011). Focal cranes were chosen systematically by starting at the furthest point to the left in the field where cranes were visible, and every 7th crane was observed from that point. The behavior of focal birds was recorded, including vigilance, foraging, preening, and head between vigilance and foraging. We also recorded the focal bird's positioning, which included facing toward the pullout, facing away from the pullout or positioned sideways to the pullout, as well as if it was hopping, flying or on the ground. Some of these categories were not mutually exclusive, for example, the bird could forage while facing away from the pullout. We recorded each time a crane changed its behavior or position and calculated a total time budget for each. Birds that flew away before the end of the five-minute interval were marked in the interval it occurred, and the observer switched to a new bird. We also visually estimated the size of each flock of cranes by counting cranes in each field, which were typically large (Figure 3). The distance of the observer vehicle to the cranes was recorded in 2011 using a standard range finder.

2.3 Human activity sampling

The number of birdwatchers and vehicles were recorded during our focal sampling bouts at sites on the refuge. We did not record human activity at sites off the refuge as there were no established pullouts, and vehicles rarely stopped there. Off the refuge, with the exception of one instance where a car pulled over at one site, my field crew and I were the only people present during our observations of cranes. The research vehicle and observers were not included in the totals recorded for birdwatchers at any site.

Crane behavior and human activity were recorded simultaneously. While one observer monitored crane behavior, another observer simultaneously recorded observations on birdwatchers every five minutes over the course of the hour at each site. The numbers of people outside vehicles, as well as the number of vehicles, were counted at each time interval, and the size of vehicles (SUV, sedan, motorcycle, or bus) was noted.

3.3 Data Analysis

A mixed linear model was used to determine the effect of location (on or off the refuge), vegetation (agriculture, wet meadow or open water), time of day (a.m. or p.m.) and flock size on the amount of time sandhill cranes spent vigilant, foraging and facing away from the pullouts. Separate behaviors (vigilance, foraging and facing away from the pullout) were not included in the same model, but rather tested independently of one another. The individual sites (interaction of vegetation and location on or off the refuge) where cranes were observed, as well as time of day, were classified as random variables to mitigate the possibility of pseudoreplication of the group of cranes sampled (Millar & Anderson 2004). A $\log_{10}$ transformation was performed on the flock size to normalize the distribution of the data for the analysis.

Canonical correlation analysis was used to relate concurrent data on sandhill crane behavior and human activity for sites on the refuge where both types of data were recorded. This analysis is useful for non-parametric data since it does not assume normality; however, it does carry the assumption of a linear relationship between crane behaviors and human activity (Hair *et al.* 1998). Canonical correlations provided information on which groupings of dependent (crane behavior) and independent (number of birdwatchers, number of vehicles, and type of vehicle) variables produced the highest overall correlation. The overall canonical correlation is determined by the canonical loadings calculated for each dependent and independent variable (Hair *et al.* 1998). Loadings with numbers closest to 1 or -1 have a larger contribution to the overall canonical correlation.

The canonical correlation analysis produced a redundancy index that is interpreted similar to the R^2 value used in linear regression models (Hair *et al.* 1998). This index indicated the grouping of independent variables (number of birdwatchers and number of vehicles by size) that best explained the variation in the group of dependent variables (crane behaviors). The redundancy index was calculated by multiplying the squared canonical correlation (R_c^2) by the average loading squared for the dependent variables. Even though there might be a high overall canonical correlation, the redundancy index provided an important measure for the true strength of the relationship between the birdwatcher and sandhill crane data sets.

3. RESULTS

I observed 144 cranes in 2010 and 347 cranes in 2011 across 12 sites for a total of 491 cranes. I observed 108 birdwatchers in 2010, and 217 birdwatchers in 2011 at the sites on the refuge for a total of 325 human observations. Both years were combined for statistical analysis since they were not significantly different from one another.

While we obtained time budgets for 9 crane behaviors and positions (Table 1), I was mainly concerned with analyzing vigilance, foraging, and time spent facing away from pullouts or the road. The average proportions for crane activity across all sites in each 5 minute interval were as follows: .47 (SE = 0.02) to foraging, .17 (SE = 0.01) to vigilance and .28 (SE = 0.01) with the head between foraging and vigilance. Cranes also had a proportion of .19 (SE = 0.01) for facing away from the visitor pullouts. Across all sites on the refuge in each 5-minute interval, the pullouts had an average of 5 (SE = 0.6) birdwatchers outside their vehicles, 2 SUV's (SE = 0.18), and 1 car (SE = 0.09). Each site on the refuge had varying levels of birdwatcher activity (Table 2), and buses did not occur at enough sites to measure their impact, except for at site 8S and CO15B, which are named for the roads on which they are located.

Cranes spent more time vigilant at locations with established pullouts on the refuge than site without pullouts off the refuge (on refuge: mean = 0.24 ± 0.031 SE; off refuge: mean = 0.15 ± 0.029 SE; t = -2.21, p = 0.08; Figure 4). Locations on the refuge versus off the refuge did not have a significant difference on time spent foraging (F = 2.60, p = 0.17) or time spent facing away from the pullout (F = 0.09, p = 0.77). Cranes spent more time foraging at agricultural fields than at the open water site (agriculture: mean = 0.54 ± 0.05 SE; open water: mean = 0.15 ± 0.14 SE; t = 4.50, p = 0.04; Figure 5). Vegetation did no t have a significant effect on the mean time spent vigilant (F = 3.41, p = 0.12) or orientation away from the pullout (F = 0.67, p = 0.55).

Cranes spent less time facing away from the pullout as flock size increased (mean = -0.28 ± 0.06 SE; t = -4.99, $p < 0.0001$). Time of day did not affect the time cranes spent vigilant (F = 0.29, p = 0.62, foraging (F = 0.01, p = 0.93) or facing away (F = 0.00 , p = 0.96) from the pullout. There also were no significant differences in the distance cranes were from the research vehicle in the 2011 dataset based on location (F = 0.12, p = 0.74), vegetation (F = 0.35, p = 0.71) or time of day (F = 0.00 , p = 0.98).

Numbers of birdwacthers and numbers of vehicles were correlated with crane behavior at two sites on the refuge: site 8S (R_c = 0.46; F = 2.69, p = 0.00019; Table 3) and the first refuge pullout (R_c = 0.70; F = 6.52, $p < 0.0001$; Table 4). The other sites on the refuge did not have significant correlations between the crane behavior and numbers of birdwatchers or numbers of vehicles (Table 5). The overall correlation for site 8S (R_c = 0.46) was determined by the proportion of time cranes spent vigilant (loading: 0.54) and facing away from the pullout (loading: 0.347), as well as the number of SUVs present (loading: -0.92) and the number of people outside of their vehicle (loading: -0.82). The positive loadings for vigilance and facing away from the pullout and negative loadings for the birdwatcher variables indicated that as the number of SUVs, buses and people outside their vehicle decreased, the proportion of time cranes spent in vigilance postures and facing away from the pullout increased. However, only 3% of the variability in crane behavior was explained by the visitor variables as shown by the redundancy index.

Another refuge site (first pullout), showed significant correlations for foraging, bird orientation and vehicle types. The variables that contributed most to the canonical correlation at the first refuge pullout site (R_c = 0.70) were the proportion of time cranes spent foraging (loading: 0.96), and facing away from the pullout (loading: -0.46), the number of SUVs present (loading: -0.41) and the number of cars present (loading: 0.43). Cranes spent more time foraging and less time facing away from the pullout at as the number of SUVs decreased and the number of cars increased. The first refuge pullout had a higher redundancy index than site 8S; but, the birdwatcher variables only explained 19% of the variability in the proportion of time cranes spent foraging or facing away from the pullout.

4. CONCLUSIONS

Migrating populations of sandhill cranes in the San Luis Valley are tolerant of birdwatchers in high traffic areas on the refuge's agriculture fields and wet meadow sites. Our findings do not correspond with results from other research where birdwatchers disturbed migratory bird species, including nesting colonial water birds (Carney & Sydeman 1999) and red-crowned cranes (Wang *et al.* 2010). These results are significant for refuge managers who are concerned with balancing a popular bird watching festival with the potential impacts on the cranes themselves.

Although the results of this study indicated that cranes spent more time in vigilance postures on the refuge versus off the refuge, birdwatchers themselves did not seem to influence how much time the birds were vigilant, foraging, or facing away from the pullouts. The proportion of time sandhill cranes invested in vigilance could have been more dependent on other natural environmental factors (e.g., birds of prey flying overhead) or anthropogenic factors (airplanes, loud noises) not accounted for in this research.

Another factor not accounted for that could have influenced the proportion of time cranes spent foraging involved sentinel cranes. Sandhill cranes have sentinel birds that alternate vigilance to scan for predators (Tacha 1988). Research on group foraging rates for Florida scrub jays (McGowan & Woolfenden 1989) as well as pied blabbers (Hollén *et al.* 2008) has shown that the presence of sentinels allows other individuals to devote more time to foraging while only a few individuals scan for predators. Sandhill cranes in the San Luis Valley may also spend more time to foraging in the presence of birdwatchers due to the presence of sentinel cranes.

Sandhill crane foraging also did not appear to be affected by the numbers of visitors to the refuge, which is highly relevant for migratory birds that need to build fat reserves to continue their journey north. The apparent ability of the cranes to tolerate bird watchers and vehicles suggests that the festival activities may not conflict with current management practices of providing food resources for migrating cranes in highly visible areas. These results suggest a successful integration of bird watching events and a tolerant charismatic species.

One cautionary note from my research is that while sandhill cranes may not appear to be significantly affected by birdwatchers, birds actively moved away from the research vehicle on the road when we pulled up to sites off the refuge, as well as when we were the first vehicle to drive into pullouts at sites on the refuge. In general, birds were closer to pullouts when they were completely empty and we could observe a gradual increase in distance from pullout starting with our own vehicle and continuing over the course of our one-hour observation period. This observation is consistent with the findings of Burger and Gochfeld (1991) on foraging shorebirds. The shorebirds moved away from the observers when they were between 10 meters to 100 meters away.

Other research has also supported creating buffer zones between human activity and wading birds of at least 100 meters or more (Rodgers & Smith 1997). Therefore, during our observation periods, the cranes could be far enough away from refuge pullouts that they are not significantly disturbed by human presence. This could pose an issue if the cranes are avoiding land near the pullouts and missing out on foraging opportunities in those areas. Overall, crane behavior appeared most influenced by flock size. As flock size increased, cranes spent less time facing away from the pullout, which could indicate that they perceived humans as less of a threat when foraging in larger groups.

This research did not support the risk-disturbance hypothesis, since cranes did not spend more time vigilant or flying away as visitor numbers increased. Cranes also did not spend more time facing away from pullouts as birdwatchers increased to the pullouts. Cranes spent some time in vigilance postures, but not enough to detract substantially from the time spent foraging, which suggests that sandhill cranes could be tolerant to the human visitors at the pullouts on the Monte Vista National Wildlife Refuge. However, tolerance of people at the refuge could have negative consequences, since people are permitted to hunt the Rocky Mountain populations of sandhill cranes outside Colorado (Colorado Parks and Wildlife 2011), while the Mid-continental population can be hunted in Colorado east of the continental divide (Kruse *et al.* 2012). If cranes do not perceive people as a threat, they may be susceptible to hunting pressure (Bejder *et al.* 2009).

Research indicates that bird species with a tolerance to non-lethal human disturbances such as bird watching will change their distributions in response to hunting activities (Madsen 1994; Casas *et al.* 2009), as well as have stronger reactions to non-lethal human activities during the hunting season (Gerhard 1994). If the cranes are tolerant to birdwatchers on the Monte Vista National Wildlife Refuge, this could be attributed to the fact that cranes are protected from hunting in the San Luis Valley. The Mid-continental population, which previously did not migrate to the valley in the spring, is hunted east of the continental divide in Colorado (Kruse *et al.* 2012). The refuge should also consider monitoring and managing for a potential increase in individuals from the Mid-continental population migrating to the San Luis Valley if these birds are changing their distribution in response to hunting pressure outside the valley. On the other hand, if these birds also become more tolerant to human activity within Colorado, they could also become more susceptible to hunting.

The U.S. Fish and Wildlife Service currently monitors the population status of the Rocky Mountain population of sandhill cranes, and is working on improvements to their estimates (Kruse *et al.* 2012). Refuges along the migratory flyway for the Rocky Mountain Population of sandhill cranes (Figure 6) should continue to coordinate with each other to assess the impact of non-lethal human activities and hunting on crane behavior.

Although this study suggests that cranes appear to tolerate birdwatchers, the Monte Vista National Wildlife Refuge should continue to monitor their activity at this important migratory stopover site, especially since the Rocky Mountain population of greater sandhill cranes is listed as a species of concern in Colorado (Colorado Parks and Wildlife 2011). The spring sandhill crane festival has been taking place for the past 29 years (Monte Vista Crane Festival 2012) and bird watching is currently a very popular recreation sport with larger numbers of visitors attending spring bird watching festivals across the country (Carver 2009; Hill *et al.* 2010). Since this festival has important economic input for the valley by attracting thousands of people that put money into local businesses, the co-management of this type of festival for both the birds and the community is critical. The refuge should continue to work with farmers, community members, visitors and municipalities to maintain this ideal resting and feeding location during the long migrations for these majestic birds that have become an integral part of the San Luis Valley ecosystem and local culture.

TABLES AND FIGURES

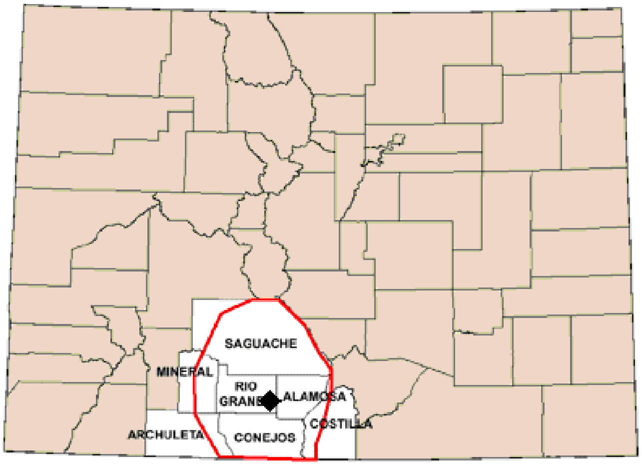

Figure 1. Location of the Monte Vista National Wildlife Refuge (black diamond) in the San Luis Valley (red outline) of Colorado, an important migratory stopover site for the Rocky Mountain population of the sandhill crane (*Grus canadensis*) (U.S. Fish and Wildlife Service 2012).

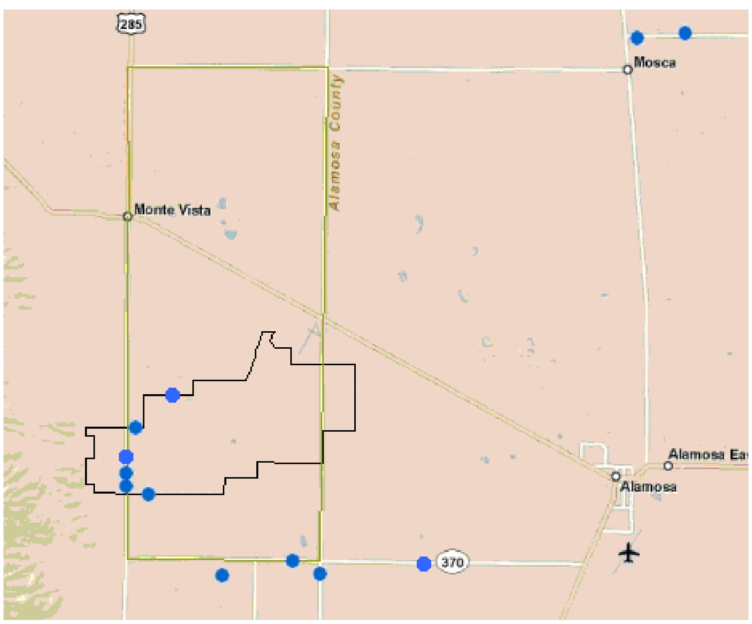

Figure 2. Sample sites (blue dots) for evaluating the behavioral responses of the sandhill crane (*Grus canadensis*) to visitors in and around the Monte Vista National Wildlife Refuge (black outline).

Figure 3. Sandhill cranes (*Grus canadensis*) landing at study site CO15B on the Monte Vista National Wildlife Refuge. The vegetation pictured is classified as Rocky Mountain alpine/montane wet meadow.

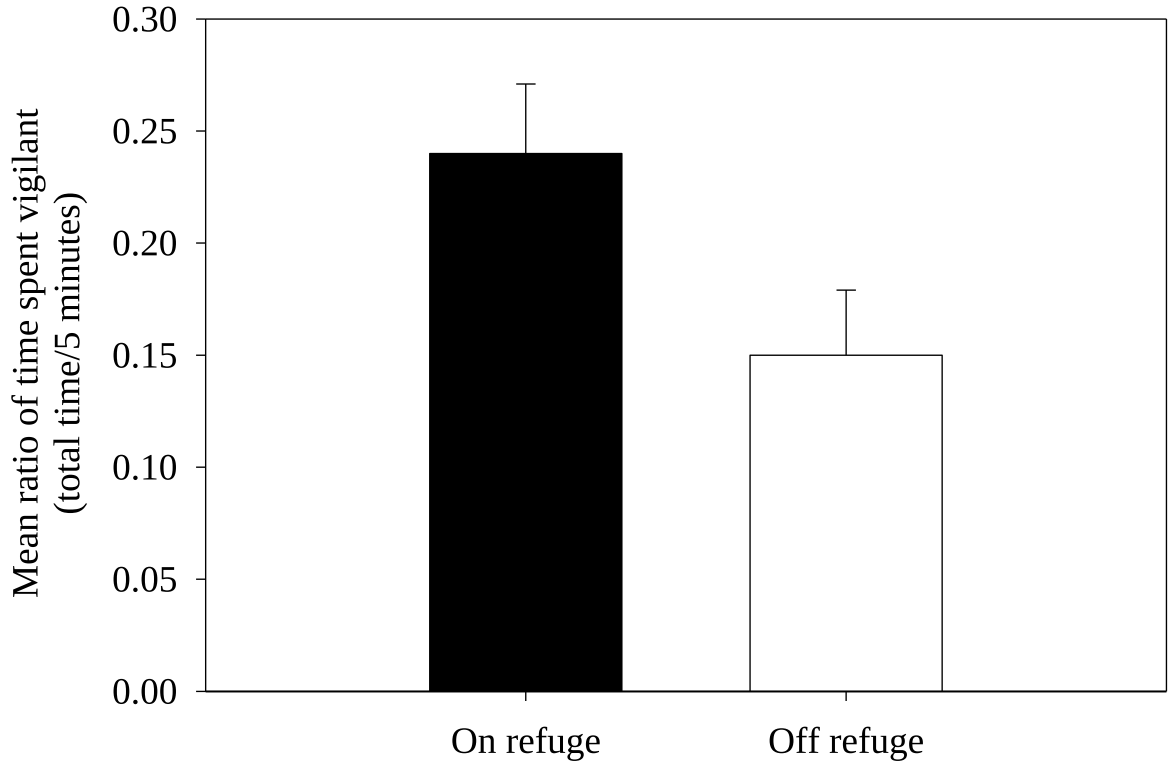

Figure 4. Sandhill cranes (*Grus canadensis*) on the Monte Vista National Wildlife Refuge spent a higher proportion of their time in vigilance postures than cranes located off the refuge (On refuge mean ± SE: 0.24 ± 0.031; Off refuge mean ± SE: 0.15 ± 0.029; t:-2.21, p: 0.078)

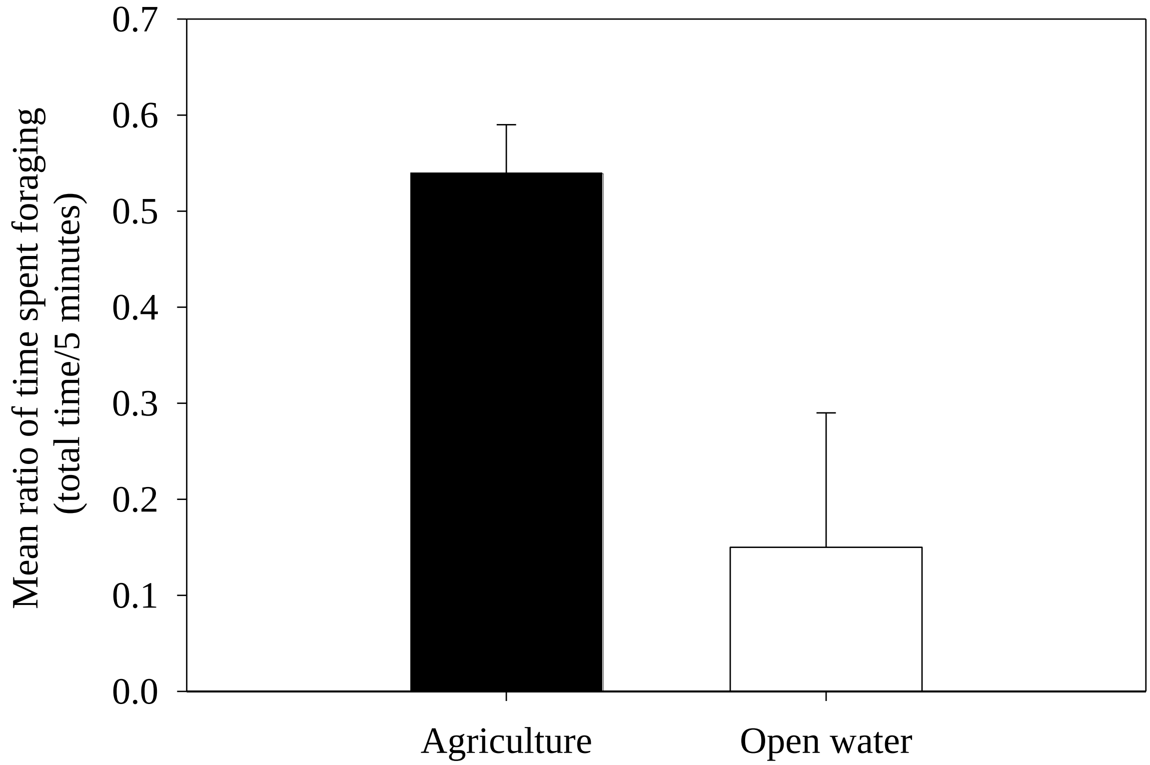

Figure 5. Sandhill cranes (*Grus canadensis*) located on agricultural fields spent a higher proportion of their time foraging than cranes located on the open water site (Agriculture mean: 0.54 ± 0.05 SE; open water: 0.15 ± 0.14 SE; t: 4.50, p: 0.043)

Figure 6. Migratory flyway for the Rocky Mountain population of the sandhill crane (*Grus canadensis*).

Table 1. Average proportions for sandhill crane (*Grus canadensis*) behaviors and positions in each five minute interval across all sites

Crane behavior/ position	**Average proportion (total time/ 5 minutes)**	**Standard Error**
vigilant	0.17	0.01
between	0.27	0.01
foraging	0.47	0.02
preening	0.04	0.01
facing forward	0.26	0.02
facing away	0.19	0.01
facing sideways	0.15	0.01
on the ground	0.51	0.02
in flight	0.003	0.001

Table 2. Total number of observations, minimums and maximums for birdwatcher variables in one 5 minute interval for sites with established pullouts (sites named after roads on which they were located or by location on the refuge's auto tour route)

Site name and total observations (n)	**Maximum**
8S, n= 120	
SUV	10
car	4
bus	3
people outside	80
first refuge pullout, n=48	
SUV	6
car	4
bus	0
people outside	12
Marsh site on refuge, n=24	
SUV	2
car	3
bus	0
people outside	3
CO15 A, n=24	
SUV	1
car	1
bus	0
people outside	2
CO15 B, n=72	

SUV	18
car	1
bus	1
people outside	69
CO15 C, n=36	
SUV	6
car	3
bus	0
people outside	5

Table 3. Results of the canonical correlation analysis for Site 8S
Canonical correlation (R_c)= 0.46, R_c^2= 0 .21
average loading^2 for dependent variables= 0.16,
redundancy index= average loading^2 * R_c^2= 0.03

	Canonical loadings
Dependent Variables	
Vigilance	0.543
Foraging	0.248
Back (facing away from pullout)	0.347
Independent variables	
SUV	-0.923
Car	-0.152
Bus	-0.674
People outside their vehicle	-0.826

Table 4. Results of the canonical correlations analysis for the first refuge site (no buses present)
Canonical correlation (R_c) = 0.70, R_c^2 = 0.49
average loading^2 for dependent variables= 0.39
redundancy index= average loading^2 * R_c^2 = 0.19

	Canonical loadings
Dependent Variables	
Vigilance	-0.157
Foraging	0.963
Back (facing away from pullout)	-0.464
Independent variables	
Suv	-0.410
Car	0.427
People outside their vehicle	0.0963

Table 5. Results of the canonical correlations analysis for sites with established pullouts on the refuge

	Site CO15A	**Site CO15B**	**Site CO15C**	**Marsh site**
Canonical correlation (R_c)	(R_c) = 0.58	(R_c) = 0.34	(R_c) = 0.36	(R_c) = 0.47
F-value, p-value	F = 1.07, p = 0.4	F = 1.14, p = 0.3	F = 0.58, p = 0.8	F = 0.55, p = 0.8
	Canonical loadings			
Dependent Variables				
Vigilance	0.049	-0.78	0.69	0.73
Foraging	-0.33	-0.19	-0.82	0.56
Back (facing away from pullout)	0.91	-0.16	-0.54	-0.50
Independent variables				
SUV	0.42	0.37	0.76	0.85
Car	0.53	0.56	-0.61	-0.43
Outside	-0.31	0.57	0.44	0.49

REFERENCES

Altmann, J. (1974). Observational study of behavior. *Behavior*, *49.3/4*, 227-67. *JSTOR*. Web. 03 Feb. 2010. <http://www.jstor.org/stable/4533591>.

Bejder, L., Samuels, A., Whitehead, H., Finn, H., Allen, S. (2009). Impact assessment research: use and misuse of habituation, sensitization and tolerance in describing wildlife responses to anthropogenic stimuli. *Marine Ecology Progress Series*, **395**, 177-185.

Burger, J. and Gochfeld, M. (1991). Human activity influence and diurnal and nocturnal foraging of sanderlings (*Calidris alba*). The Condor, **93**, 259-265.

Burger, J. (1994). The effect of human disturbance on foraging behavior and habitat use in piping plover (*Charadrius melodus*). *Estuaries*, **17**, 695-701.

Burger, J., and Gochfeld, M. (2001). Effect of human presence on foraging behavior of sandhill cranes (*Grus Canadensis*) in Nebraska. *Bird Behavior*, **14**, 81-87.

Carney, K.M. and Sydeman, W.J. (1999). A review of human disturbance effects on nesting colonial waterbirds. *The International Journal of Waterbird Biology*, 22, 68-79.

Carr, J.M., and Lima, S.L. (2010). High wind speeds decrease the responsiveness of birds to potentially threatening moving stimuli. *Animal Behaviour*, **80**, 215-220.

Carver, E. (2009). *Birding in the United States: A demographic and economic analysis. Addendum to the 2006 National Survey of Fishing, Hunting and Wildlife-Associated Recreation.* Arlington, VA: U.S. Fish & Wildlife Service.

Casas, F., Mougeot, F., Vinuela, J. and Bretagnolle, V. (2009). Effects of hunting on the behavior and spatial distribution of farmland birds: importance of hunting-free refuges in agricultural areas. *Animal Conservation*, **12**, 346-354.

Case, D.J. and Sanders, S.J., eds. (2009). Priority information needs for sandhill cranes: a funding strategy. Special report in the files of the *Central Flyway Representative*. Denver, CO., 13

Colorado Parks and Wildlife (April 13, 2011). *Sandhill Crane.* Retrieved March 26, 2012, from http://wildlife.state.co.us/WildlifeSpecies/Profiles/Birds/Pages/SandhillCrane.aspx

Fernández-Juricic, E., Jimenez, M.D., and Lucas, E. (2001). Alert distance as an alternative measure of bird tolerance to human disturbance: implications for park design. *Environmental Conservation*, **28**, 263-269.

Frid, A. and Dill, L. (2002). Human-caused Disturbance Stimuli as a Form of Predation Risk. Conesrvation Ecology, **6**, 11-26.

Gerhard, M. (1994) Ursachen und kurzfristige Aus- wirkungen von St6rungen auf den Wasservogelbestand des Biebersteiner Weihers. *Charadrius,* **30**, 70-76. (In German)

Gill, J.A. (2007). Approaches to measuring the effects of human disturbance on birds. *Ibis,* **149**, 9-14.

Hair, J., Anderson, R.E., Tatham, R.L., and Black, W.C. (1998). *Multivariate Data Analysis, 5th edition.* Prentice Hall, Inc.

Haufler, J. B., editor (2005). Fish and wildlife benefits of Farm Bill conservation programs: 2000-2005 update. *The Wildlife Society,* Technical Review, 05-2

Hill, S.G., Cable, T.T., Scott, D. (2010). Wildlife-based recreation as economic windfall: a rhetorical analysis of public discourse on birding. *Applied Environmental Education and Communication*, **9**, 224-232

Hollén, L.L., Bell, M.B.V., Radford, A.N. (2008). Cooperative sentinel calling? Foragers gain increased biomass intake. *Current Biology*, **18**, 576-579.

Kim, C., Scott, D., Thigpen, J.F., Kim, S. (1998). Economic impact of a birding festival. *Festival Management and Event Tourism*, **5**, 51-58.

Kruse, K.L., Dubovsky, J.A. and Cooper, T.R. (2012). Status and harvests of sandhill cranes: Mid-Continent, Rocky Mountain, Lower Colorado River Valley and Eastern Populations, pp 5-8. Administrative Report, U.S. Fish and Wildlife Service, Denver, Colorado.

Laubhan, M.K. (2001). Agricultural Producers' Perceptions of Sandhill Cranes in the San Luis Valley of Colorado. *Wildlife Society Bulletin*, **29**, 639-45.

Liley, D. and Sutherland, W.J. (2007). Predicting the population consequences of human disturbance for Ringed Plovers *Charadrius hiaticula*: a game theory approach. *Ibis*, **149**, 82-94.

Lima, S. (1995). Back to the basics of antipredatory vigilance: the group-size effect. *Animal Behaviour*, **49**, 11-20.

Lingle, S. and Wilson, W.F. (2001). Detection and avoidance of predators in white-tailed deer (*Odocoileus virginianus*) and Mule deer (*O. hemionus*). *Ethology*, **107**, 125-147.

Madsen, J. (1994). Impacts of disturbance on migratory waterfowl. *Ibis*, **137**, 67-74.

McGowan, K.J. and Woolfenden, G.E. (1989). A sentinel system in the Florida scrub jay. *Animal Behaviour*, **37**, 1000-1006.

Millar, R.B. and Anderson, M.J. (2004). Remedies for pseudoreplication. *Fisheries Research*, **70**, 397-407.

Monte Vista Crane Festival (March 2012). *Celebrating Spring in the Valley of the Cranes.* Retrieved May 20, 2012 from http://www.cranefest.com/index.html.

Newton, I. (2006). Can conditions experienced during migration limit the population levels of birds? Journal of Ornithology, **147**, 146-166.

Pfister, C., Harrington, B.A., and Lavine, M. (1992). The impact of human disturbance on shorebirds at a migration staging area. *Biological Conservation*, **60**, 115-126.

Roberts, G. (1996). Why individual vigilance decreases as group size increases. *Animal Behaviour*, **51**, 1077-1086.

Rodgers, Jr., J.A. and Smith, H.T. (1997). Buffer zone distances to protect foraging and loafing waterbirds from human disturbance in Florida. *Wildlife Society Bulletin*, **25**, 139-145.

Rodriguez-Prieto, I., Fernández-Juricic, E., Martín, J., and Regis, Y. (2008). Antipredator behavior in blackbirds: habituation compliments risk allocation. *Behavioral Ecology*, **20**, 371-377.

Scott, D. and Thigpen, J. (2003). Understanding the birder as tourist: segmenting visitors to the Texas hummer/bird celebration. *Human Dimensions of Wildlife: An International Journal*, **8**, 199-218

Sekercioglu, C.H. (2002). Impacts of birdwatching on human and avian communities. *Environmental Conservation*, **29**, 282-289.

Skagen, S.K. (2006). Migration stopovers and the conservation of artic-breeding calidrine sandpipers. *The Auk*, **123**, 313-322

Stoll, J.R., Ditton, R.B., Eubanks, T.L. (2006). Platte River birding and the spring migration: humans, value, and unique ecological resources. *Human Dimensions of Wildlife: An International Journal*, **11**, 241-254.

Tacha, T.C., Vohs, P.A, and Iverson, G.C. (1987). Time energy and budgets of sandhill cranes from mid-continental North America. *The Journal of Wildlife Management*, **51**, 440-448.

Tacha, T.C. (1988). Social-organization of sandhill cranes in Midcontinental North-America. Wildlife Monographs, **99**, 1-37.

Terhune, J.M. and Brillant, S.W. (1996). Harbour seal vigilance decreases over time since haul out. *Animal Behaviour*, **51**, 757-763.

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

U.S. Fish and Wildlife Service. (2003). *Alamosa-Monte Vista National Wildlife Refuge Complex: Comprehensive Conservation Plan*. Denver, Colorado: U.S. Department of the Interior, Fish and Wildlife Service, Mountain–Prairie Region, 57.

U.S. Fish and Wildlife Service. (June 24, 2011). Alamosa/Monte Vista/Baca National Wildlife Refuge Complex. In *Monte Vista National Wildlife Refuge: Insuring habitat integrity*. Retrieved March 26, 2012, from http://www.fws.gov/alamosa/Monte%20Vista.html.

U.S. Fish and Wildlife Service. (May 2012). San Luis Valley Focus Area map. Retrieved June 26, 2012, from http://www.fws.gov/mountainprairie/pfw/ colorado/co34.htm.

USGS National Gap Analysis Program. (2004). Provisional Digital Land Cover Map for the Southwestern United States. Version 1.0. RS/GIS Laboratory, College of Natural Resources, Utah State University.

Verhust, S., Oosterbeek, K., and Ens, B.J. (2001). Experimental evidence for effects of human disturbance on foraging and parental care in oystercatchers. *Biological Conservation*, **101**, 375-380.

Wang, Z., Li, Z., Beauchamp, G., and Jiang, Z. (2010). Flock size and human disturbance affect vigilance of endangered red-crowned cranes (*Grus japonensis*). *Biological Conservation*, **144**, 101-105.

Yasue, M. (2005). The effects of human presence, flock size and prey density on shorebird foraging rates. *Journal of Ethology*, **23**, 199-204