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# Nesting Behaviors Of Sharp-Tailed Grouse (*tympanuchus Phasianellus*) Using Camera Technology

Rebecca Ann Kludt

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NESTING BEHAVIORS OF SHARP-TAILED GROUSE (*TYMPANUCHUS  
PHASIANELLUS*) USING CAMERA TECHNOLOGY

by

Rebecca Ann Kludt  
Bachelor of Science, University of North Dakota 2013

A Thesis  
Submitted to the Graduate Faculty

of the

University of North Dakota

in partial fulfillment of the requirements

for the degree of

Master of Science

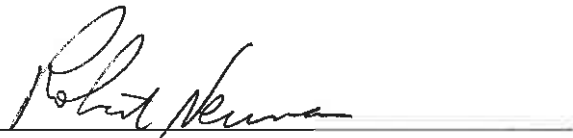
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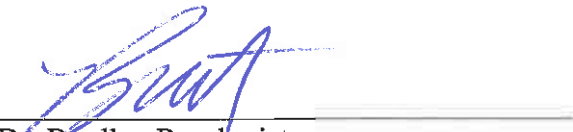
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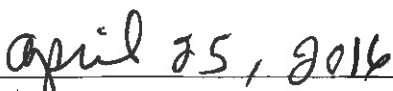
  
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## ABSTRACT

Increasing demands for oil, biofuels and food have posed several issues for grassland birds in the upper Midwest. Conversion from grassland to cropland and avoidance of anthropogenic features has greatly reduced the amount of suitable habitat for many grassland birds; therefore, it is necessary to monitor the life history and demographics of these species, especially those who are indicators of grassland health. Nest attendance (i.e. how incubating parents spend time on the nest) is an important component of reproductive ecology and can serve as one of the first indicators of stress induced by changes on the landscape. Camera monitoring using continuously recording surveillance cameras is one technique researchers use to observe nest attendance patterns; however, the influence of behaviors in response to camera monitoring on nest survival is largely unknown. The objectives of this study were to determine (1) if and how characteristics of the hen, nest and landscape influence nest attendance patterns, and (2) if behaviors resulting from camera monitoring influence daily nest survival rates. During the summers of 2012 and 2013 we radio-collared and monitored 103 nests of Sharp-tailed Grouse (*Tympanuchus phasianellus*) hens using continuously recording surveillance cameras. To address our first objective, we reviewed video from 55 nests from the day after camera installation until nest fate. We used repeated measures and multi-model inference approaches to determine if landscape characteristics (including anthropogenic features and important land cover) at three scales and characteristics of the hen and nest

influence nest attendance patterns. For our second objective we reviewed video from 70 nests during the first 24 hours after camera installation. We noted how hens returned to the nest, nest attendance patterns, and if they had an interaction with the camera. We constructed daily nest survival rate models using the previously listed behaviors and used multi-model inference to rank models and evaluated model-averaged parameter estimates. In addition, we compared incubation constancy (i.e. the proportion of time eggs receive heat from incubating hens during a 24 hour period) between camera installation day, days when hens were flushed to check the nest, and days with no researchers present. Results from the first objective revealed lower nest attendance during 2013 and at Blaisdell where there was less oil development and lower apparent nest success. In addition we noted only two nests to be within 250 m of an active oil well. Overall, it appears that large scale (site level) differences are driving patterns of nest attendance and predation and that further investigation into nest site selection, brood success, hen survival, lek attendance and specific characteristics of anthropogenic disturbances are needed to fully understand the influence of the landscape on reproduction. For our second objective we found that the way hens approach the nest was the only predictor of daily nest survival rates, and that incubation constancy was lower compared to days when researchers were not present. We found that behaviors relative to camera monitoring did not greatly influence nest success; therefore, we recommend cameras as a valuable tool to study the impact of the changing landscape on nesting ecology.

## CHAPTER I

### BACKGROUND AND LITERATURE REVIEW

Native gamebirds play an important role in the U.S. economy. In 2011, more than 2.4 million hunters spent approximately 22 million days hunting upland gamebirds in the U.S. (Southwick 2012). In addition, these hunters spent more than \$2.8 billion on costs associated with hunting trips including hunting equipment, lodging, and licenses (Southwick 2012). In rural areas, some small businesses depend on income made during the hunting season (Southwick 2012). Upland game hunters in North Dakota provided 384 jobs and were collectively paid more than \$12 million (Southwick 2012). Many native gamebirds also serve as representatives for conservation. Money spent on upland gamebird habitat supports other species that have similar habitat requirements. Several native gamebirds such as Sharp-tailed Grouse (*Tympanuchus phasianellus*) and Greater and Lesser Prairie-Chickens (*Tympanuchus cupido* and *Tympanuchus pallidicinctus*, respectively) serve as indicators for grassland health (Vodehnal and Haulfer 2007, Dyke et al. 2011).

Gamebird contributions to ecosystems and the economy depend on their ability to persist on the landscape. Nesting ecology, a major component of population dynamics, is commonly monitored to ensure health of the population. Given the changing land uses where gamebirds exist, there is a need to understand relationships between their nesting ecology and other population demographics relative to these changes with North Dakota

representing one of areas with rapid expansion of agriculture (Rashford et al. 2010, Wright and Wimberly 2013) and gas and oil development in recent years (Nordeng 2010, Walton 2015).

## **Birds and Multi-use Landscapes**

### *Agriculture*

Agricultural production is on the rise in order to accommodate the growing food demands across the globe, and this has resulted in dramatic shifts in land use across North America (Wright and Wimberly 2013). In the 2012 Census of Agriculture, the U.S. Department of Agriculture (USDA), National Agriculture Statistics Service (NASS) reported an increase of approximately 1.4 million harvested cropland acres between 2007 and 2012, and 2.8 million acres since 1997 in North Dakota. Conversely, hay and pasture land decreased by more than 140,000 ha (350,000 acres) between 2007 and 2012. Market value of agricultural products sold has increased from approximately \$5 billion in 2007 to more than \$10 billion in 2012 along with an increase of \$2.9 billion in total farm production expenses. North Dakota has also had a decrease in the number of cattle calf operations between 2007 and 2012. In addition, Conservation Reserve Program (CRP) acreage enrollment in North Dakota has seen a decline (USDA 2013). With greater profits and grassland conversion, wildlife populations must adapt to thrive in the dynamic agricultural landscape.

The effect of row crop agriculture on birds varies greatly. For example, many grassland songbirds show strong, negative responses to habitat fragmentation, reduction of grassland area, and increase in row cropped area (Koper and Schmiegelow 2006). Conversely, many upland nesting gamebird and waterfowl species utilize crops as food



sources, and therefore respond much more positively when crops are included on the landscape (Koper and Schmiegelow 2006, McNew et al. 2011). In Kansas, female Greater Prairie-Chickens were significantly heavier, produced larger eggs, and had higher nest and brood survival at sites with 37% cropland compared to sites with only 3% cropland (McNew 2011). Although some grassland bird species, such as prairie grouse, use row crops, it is important to note that usage depends on life stage and time of year (Hovick et al. 2014), and that relationship is not linear because of the necessity of grassland for cover (Connelly et al. 1988).

Effects of various grazing schemes also vary in ways they influence different bird species. Most upland gamebirds fare well in pastures under rest-rotation or deferred-rotation grazing system that provide preferential nesting habitat while limiting time of disturbance (Holechek et al. 1982). Even though the densities of nests at non-grazed pastures were double that of grazed, Kirby and Grosz (1995) found that apparent nest success of Sharp-tailed Grouse was 30% greater in grazed pastures. Many grassland song birds are also supported by grazed pastures. Therefore, incorporation of grazing schemes at varying intensities can simultaneously occur on the landscape to meet initiatives for conservation and working lands (Coppedge et al. 2008).

#### *Natural Gas and Oil Production*

Gas and oil production has long been a part of North Dakota's landscape (NDIC 2013). The North Dakota Industrial Commission, Department of Mineral Resources, Oil and Gas Division (hereafter "NDIC Oil and Gas Division") is responsible for regulation of drilling, production, and statistical reporting within the state. Annual oil production has exponentially grown, increasing from approximately 32 million barrels in 2000 to

nearly 400 million barrels in 2014. The number of producing wells has also risen by more than 9,000 wells within that 14-year period. To support this development the construction of new roads to connect energy infrastructure and improvements to existing roads have increased to safely accommodate the growing human population and need to transport goods (NDDOT 2013).

This rapid increase in energy development experienced across North America has sparked the need to understand its impact on wildlife. Many bird species show avoidance of anthropogenic structures, including roads in response to gas and oil development. Gilbert et al. (2011) found negative correlations between oil well density abundance of Brewer's Sparrows (*Spizella breweri*), Sage Sparrows (*Amphispiza belli*), and Vesper Sparrows (*Pooecetes gramineus*). In addition, they determined that response to oil well density was stronger in areas with active drilling suggesting that other disturbances associated with gas and oil production (e.g. well pad construction, well drilling, jack pump installation, associated truck traffic, etc.) also influence bird densities (Gilbert et al. 2011). Thompson et al. (2015) observed similar avoidance patterns to roads (150m) and well pads (150m to 267m) by grassland songbirds in North Dakota. Changes in vegetation composition from sagebrush steppe to dusty grassland resulting from road traffic in oil fields in western Wyoming gave rise to shift from sagebrush obligate bird communities to those dominated by Horned Larks (*Eremophila alpestris*) (Ingelfinger and Anderson 2004), a grassland species that is associated with areas of sparsely vegetated grassland and agricultural use (Beason 1995).

Responses to anthropogenic development have been predominantly studied in two species: Greater Sage-Grouse (*Centrocercus urophasianus*) and Lesser Prairie-Chickens

(Hovick et al. 2014). Walker et al. (2007) reported that loss of sagebrush habitat and structures associated with gas and oil development significantly decreased both number of leks and male Greater Sage-Grouse attendance. Female Greater Sage-Grouse have displayed avoidance of preferable winter habitat because of natural gas development (Doherty et al. 2008). Female Lesser Prairie-Chickens in Kansas avoid nesting near anthropogenic features by selecting sites 150 m to 1000 m away from disturbances (Pitman et al. 2005).

### **Use of Cameras for Monitoring Birds**

With increasing globalization there is a need to study influences of anthropogenic changes (e.g. land use changes, habitat fragmentation, increased energy development, etc.) on wildlife populations. Techniques to monitor population responses focus on demographic rates that influence survival and reproduction. For birds, nesting is one of the most important aspects of reproduction; however, events during the nesting period for many avian species remain unknown largely because of logistical challenges of observing the nest. Dense cover at nests, cryptically colored attending adults, and/or limited access to nest locations pose challenges when observing many avian species (Ellis-Felege and Carroll 2012). Using nest cameras allows researchers to observe events that would remain unknown without the presence of a camera or human observer.

Nest predator identification, parental care, and nestling behavior are common objectives of interest in studying responses to landscape changes and can be monitored using nest cameras (Ellis-Felege and Carroll 2012, Pietz et al. 2012a). Correct identification of nest fate and predators can help to detect changes in predator communities in response to land-use change and energy development (Burr 2014), and

can lead to more effective predator management if they are found to be major sources of nest failure (Thompson and Ribic 2012). Video evidence can allow for accurate nest fate identification and predators when sign at the nest may be unreliable (Pietz and Granfors 2000, Staller et al. 2005). Land-use changes may not only alter habitat of nest predators but of the nesting species as well. Coates and Delehanty (2008) used nest cameras to examine how hen age, nest characteristics, and habitat composition near Greater Sage-Grouse nests influence parental care in the form of nest attendance patterns; a manifestation of the fitness tradeoffs attending parents face.

Technological advancements and greater affordability have contributed to the increased use of cameras for nest monitoring. Although their use has greatly expanded our knowledge of nesting ecology, our understanding of how camera monitoring techniques influence target species interest is still limited. Failure to understand such impacts may result in inferences predicated on bird responses to cameras rather than the greater environment, or unnecessary increases in nest failure because of research activities. Traditional methods of evaluating impacts of cameras on nesting birds have included calculating apparent nest success (nest considered successful if  $\geq 1$  egg hatches), daily nest survival, predation rates, and abandonments within 72 hours of nests monitored with and without cameras (Brown et al. 1998, Pietz and Granfors 2000, Stake and Cimprich 2003, McKinnon and B  ty 2009). Few studies report alterations of animal behaviors because of camera presence (Brown et al. 1998, McGowan and Simons 2006), and to our knowledge no one has evaluated if or how behaviors associated with camera installation are related to nest success.

## **Sharp-tailed Grouse Ecology**

Sharp-tailed Grouse (hereafter “sharptail” or “sharptails”) are a medium-sized, ground-nesting upland game bird found throughout the grasslands of North America (Connelly et al. 1998). Beginning in March, males begin to dance at breeding grounds known as leks (Connelly et al. 1998). Females begin to arrive at leks in early April to reproduce (Connelly et al. 1998). Nest initiation occurs between April and July (Marks 2007). Only females invest in parental care activities such as incubation and brood rearing. Average clutch size is 12 eggs, with an incubation period of 21 to 25 days (Marks 2007). In some areas, sharptails have been observed to re-nest up to four times per season if a clutch is lost (Connelly et al. 1998). Nesting habitat may include areas with trees, dense brush, and thick, tall grassland areas (Connelly et al. 1998, Johnsgard 2008).

Population health of sharptails across North America has been declining because of changes in land use and habitat loss (Kirsch et al. 1973, Marks 2007, Johnsgard 2008). In North Dakota, sharptail populations are thought to be stable (Dyke et al. 2011); however, the impact of energy development and agricultural practices on these populations have been understudied (Hovick et al. 2014). Dramatic increases in western North Dakota energy development have presumably threatened sharptail habitat and their behaviors (Dyke et al. 2011, NDIC 2015). In a meta-analysis Hovick et al. (2014) found that oil and natural gas structures and roads displaced prairie grouse during all life stages, especially at leks. These findings prompt questions of how energy development might influence other harder to observe behaviors. Knowledge regarding nesting ecology of

sharp-tailed grouse is sparse, with little understanding regarding the impact of gas and oil development on the species (Hovick et al. 2014).

Given sharptails are taxonomically grouped with the prairie grouse which include the Greater and Lesser Prairie-Chickens (collectively referred to as “prairie-chickens”) much of the current sharptail management is modeled after prairie-chicken and Greater Sage-Grouse responses to disturbances associated with gas and oil production (Pitman et al. 2005, Coates et al. 2008). Since literature regarding impacts of human disturbance and land-use change is more abundant for prairie chickens (Hovick et al. 2014) and given the genetic and ecological similarities between prairie chickens and sharptails, our hypotheses about the impact of nest, hen, and habitat characteristics on nest attendance are modeled after prairie chickens.

### **Avian Incubation**

Tradeoffs exist between the needs of the parent and of the offspring with life history characteristics driving parental investment patterns among species. A large body of literature has shaped parental investment theories and reasons for variation in parental investment (Stutch 1963, Montgomerie and Weatherhead 1988). For incubating birds, this tradeoff can be observed by monitoring nest attendance patterns. A nest is considered attended if a parent is either incubating eggs or brooding chicks at the nest. When the parent is not attending the nest they are considered to be on recess (Skutch 1963). During this time, adults will take time for self-maintenance activities such as foraging (Skutch 1963). For birds that need to camouflage both themselves and their nests from predators, limited movement is critical for reducing potential detection by predators. Incubation constancy, or the percent time spent attending a nest either during a

24-hour period or daylight hours applying heat to eggs, is needed to fully understand activity budgets and movement at the nest (Skutch 1963). These parental investment measures vary by species, individual and ecosystem depending on physiological and environmental constraints.

Parental care may also be affected by nest age (Brunton 1990) and timing during the breeding season (Burnam et al. 2012). For example, birds with higher re-nesting potential should defend their nest less, exhibiting the tradeoff between clutch and parent fitness (Montgomerie and Weatherhead 1988). As the nesting season progresses, clutch size decreases with each nesting attempt as a direct result of reduced body mass from continued nesting effort (Ankney and Afton 1988, Pitman et al. 2006). Weather patterns also may affect nest attendance behaviors. Late spring and early summer, when cold and rainy weather is frequent, hen Northern Shovelers (*Anas clypeata*) were observed to increase incubation constancy; however, later in the summer, they were anecdotally observed to have longer recesses during late afternoon at times of warm ambient temperatures (Afton 1980).

### **Study Objectives and Hypotheses**

The goal of this study is to examine nesting ecology of sharptails through the use of nest cameras. Factors that influence nest attendance patterns (e.g. hen characteristics, attributes of the nest, landscape features, and disturbances) in sharp-tailed grouse are explored in Chapter 2. Secondly, we investigated the potential impacts of behaviors expressed within 24 hours after camera installation on daily nest survival rates (DSR) to validate current procedures used to study ground-nesting birds with cameras (Chapter 3). Finally, we describe conclusions on sharp-tail nesting ecology and make

recommendations for future nesting studies using cameras for ground-nesting bird research and monitoring.

To evaluate sharptail nesting behaviors and responses to cameras, we specifically examined the following *a priori* hypotheses for each objective.

*Objective 1 (Chapter 2): How does nest attendance for sharp-tailed grouse vary relative to different landscape and land-use patterns?*

1. Hens with nests situated in heterogeneous landscapes providing food and other important resources with relatively few anthropomorphic features will spend more time on the nest, leave less frequently, and for shorter amounts of time. Avoidance behaviors to anthropogenic features associated with energy development and human expansion have been documented in grouse nest site selection (Manzer and Hannon 2005, Hovick et al. 2014), and may have to spend more time avoiding anthropogenic features while foraging.

2. Hens that are older, on late season nesting attempts, or that have larger clutches display strong parental investment behaviors spending more time on the nest, leave less frequently, and for shorter amounts of time. Parental investment characteristics are also known to influence nest success, and have been studied relative to nesting dynamics in birds with a variety of hen (e.g., age) (Yerkes 1998) and nest characteristics (e.g., timing in nesting season, nest attempt, and clutch size) (Thompson et al. 1998, Pavel and Bures 2008, Burnam et al. 2012).



3. A combination of landscape and hen and nest characteristics best describe nest attendance patterns, rather than a single driver of parental investment or environmental pressures.

4. Neither landscape or hen and nest characteristics appropriately predict nest attendance patterns, and instead other factors not measured such as predator communities or microhabitat characteristics might drive nesting behaviors.

*Objective II (Chapter 3): How do daily survival rates of nests change relative to grouse behaviors after a camera is installed?*

1. Daily survival rates are higher for nests where hens spend more time on the nest, and take fewer recesses during the first 24 hours after camera installation. Hens leaving nests unattended for long periods of time exposes sensitive eggs to potentially inclement weather and predators (Afton 1980). Long absences in incubation can slow development, and these effects are exacerbated during periods of cold and wet weather (Afton 1980).

2. Daily survival rates are lower for nests where hens do not immediately resume incubation upon return to the nest. The way in which the hen returns after camera installation (e.g., sits next to, partially on, or directly on the nest) may be associated with nest success. Prolonged time spent moving frequently within the vicinity of the nest may cue predators to nest location. Therefore, it should be advantageous for hens to quickly return to the nest following camera installation. The same logic can be applied to frequent or prolonged recess events.

3. Daily survival rates are lower for nests where hens have a camera interaction within the first 24 hours after camera installation. Movements of the hen around the nest may result in increased detection of nests by predators. Time and energy spent defending the nest against the camera may influence nest success by altering time spent incubating, and by increasing the chances of nest predation.

4. As the duration of researcher interaction increases, incubation constancy decreases, which may translate to reduced nest survival. Harvey (1971) observed that failed Blue Goose (*Chen caerulescens*; now classified as Snow Geese) nests had parents that were less attentive compared to successful nests supporting the hypothesis that reduced attentiveness (i.e. less protection) increases the probability of predation.

### **Study Sites**

As part of a large collaborative project exploring impacts of gas and oil on sharp-tailed grouse demographics, we conducted field work for this study at two sites, Belden (centroid location: N 48.107922, W 102.393517) and Blaisdell (centroid location: N 48.107922, W 102.393517), located in Mountrail County in western North Dakota (Figures 1). These sites lie on the eastern edge of natural gas and oil development and are defined by the relative gas and oil activity within their bounds. Nests located at Belden (Figure 2) are located in areas of higher oil well and road density than those in Blaisdell (Figure 3). Both sites are dominated by agricultural land-cover types including row crop fields, and pasture lands with scattered small water bodies and clusters of deciduous trees. Rolling hills, buttes, and draws are common geomorphic features on the landscape. Thus, the area provided an ideal location to evaluate sharptail nesting ecology

in the face of a variety of landscape characteristics, while validating nest camera technology to further understand implications of researcher methods.

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Figures

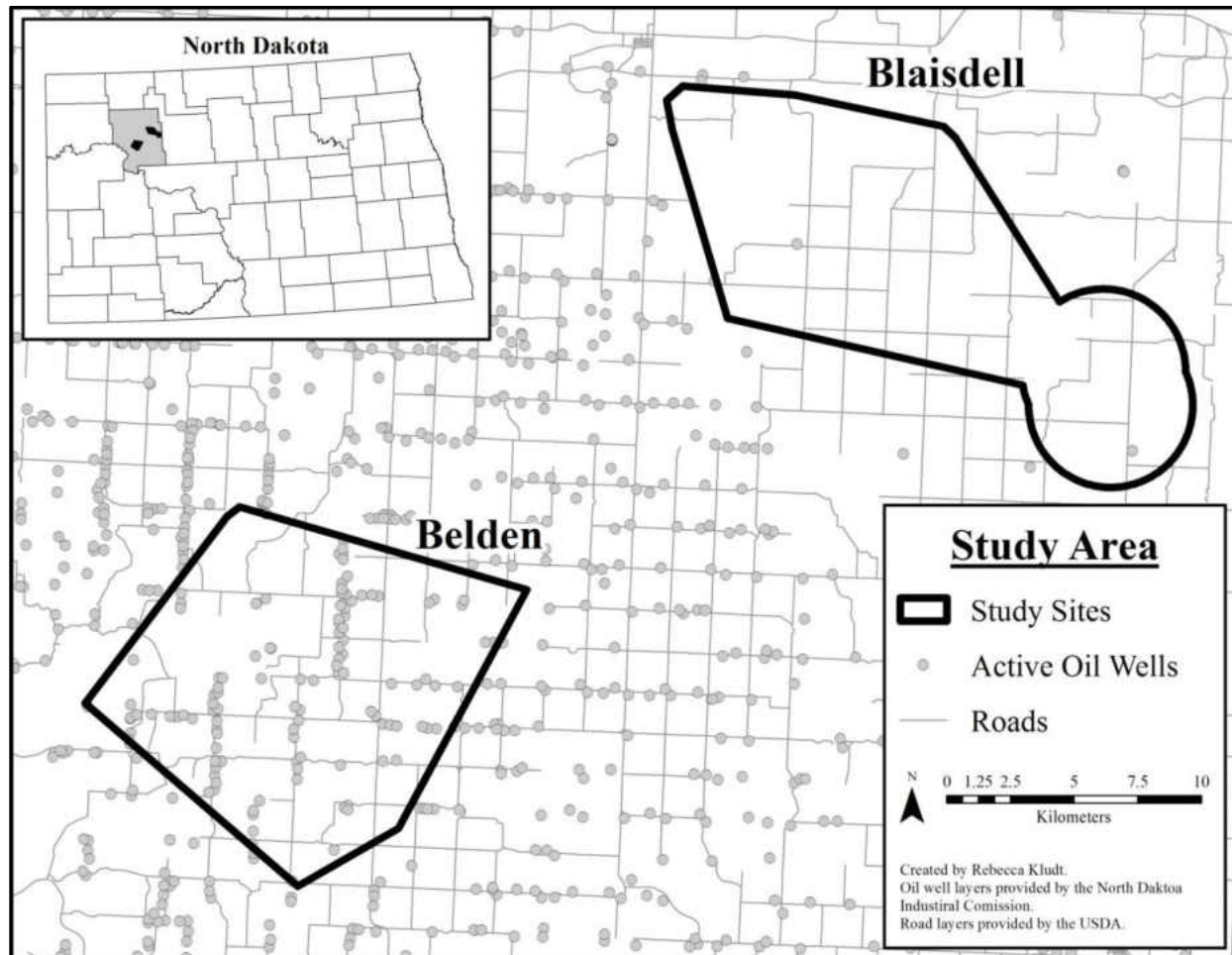


Figure 1. Study sites, roads, and active oil wells located in Mountrail Co. North Dakota.

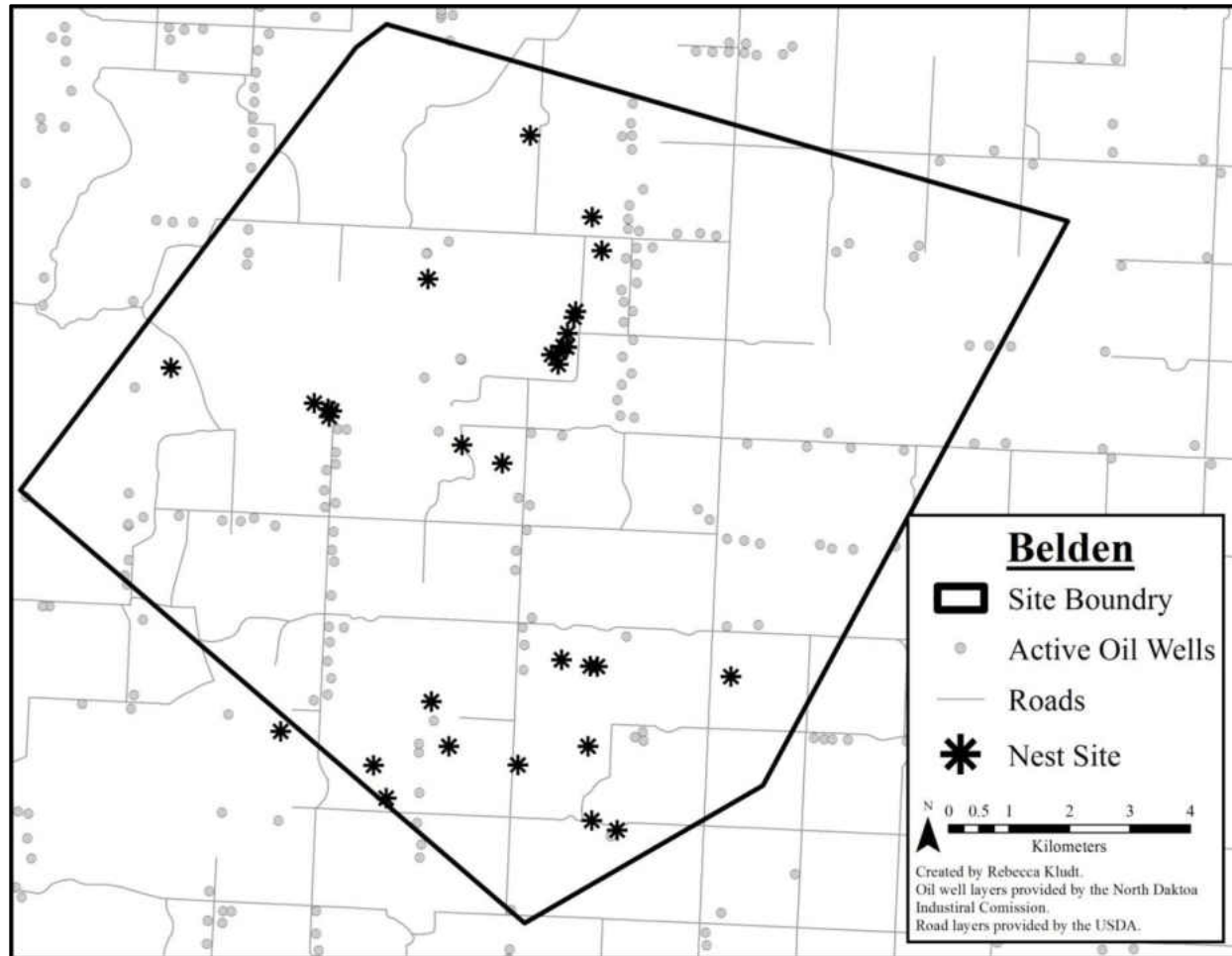


Figure 2. Belden nest locations, oil wells, and roads. Belden was our study site of “high” gas and oil intensity with an oil well density of  $0.076 \text{ wells/km}^2$  in 2012, and  $0.950 \text{ wells/km}^2$  in 2013. A total of 26 nests from this site were monitored and nest attendance patterns reviewed.

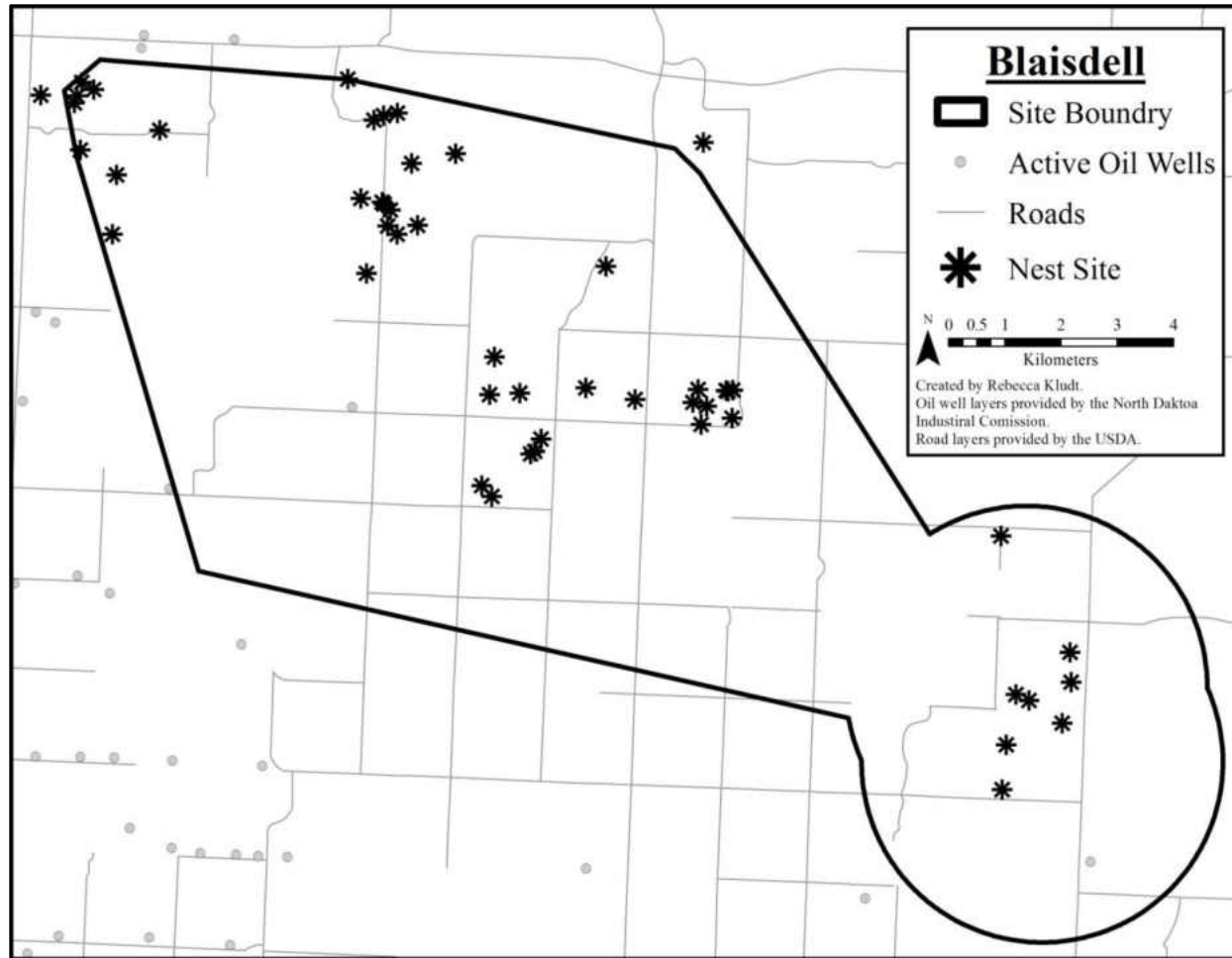


Figure 3. Blaisdell nest locations, oil wells, and roads. Blaisdell was our study site of “low” gas and oil intensity with no oil wells during 2012 and an oil well density of  $0.006 \text{ wells/km}^2$  in 2013. A total of 29 nests from this site were monitored and nest attendance patterns reviewed.

## **CHAPTER II**

### **NEST ATTENDANCE PATTERNS OF SHARP-TAILED GROUSE IN WESTERN NORTH DAKOTA**

#### **Abstract**

Land use changes and increased gas and oil development in the upper Great Plains has generated the need to evaluate their influence on the region's wildlife populations. Sharp-tailed grouse (*Tympanuchus phasianellus*) are an important game species that face pressures from these anthropogenic practices. Nesting behaviors are one of the least understood aspects of sharptail ecology. By studying nest attendance patterns, we can observe the tradeoff between the health of the hen and success of the nest, one of the major contributors of population dynamics. The objectives of this study are to (1) quantify nest attendance patterns, and (2) determine if/how nest attendance varies depending on the surrounding landscape. We reviewed continuously recorded video from 55 nests of radio-collared sharptail hens from the summers of 2012 and 2013 in an area of high and an area of low energy development intensity. Incubation constancy, duration, and number of recesses were calculated for each day. We calculated percent grass, developed, and fallow land as well as oil well density within 250 m, 450 m, and 800 m of each nest. We used multi-model inference to evaluate how characteristics of the hen, nest, and landscape influence nest attendance. Hens incubated for approximately 95.2% of the day (SD = 3.3%) and took 2.5 recesses (SD = 1.2) for 27.6 minutes (SD = 23.5) in duration. Year was the only parameter to predict nest attendance

patterns; however, we did find general trends of decreased parental investment in sites with low intensity natural gas and oil development compared to sites of high intensity development and lower nest success. These findings suggest that further research is needed to fully understand the impacts that the landscape and energy development have on reproductive ecology of Sharp-tailed Grouse.

## **Introduction**

Grasslands of the upper Midwest are undergoing dramatic changes. Increased need for food and biofuels has forced the conversion of grassland to row crop agriculture such as corn and soybeans (Wright and Wimberly 2013). Between 2002 and 2012, North Dakota has experienced a decrease of 2.7 thousand ha (665 thousand acres) of grassland, a reduction in the number of cattle-calve operations, and an increase of 1.5 million ha (3.6 million acres) of harvested cropland (USDA 2014). In addition, western North Dakota's oil and natural gas production dramatically increased from approximately 33 million barrels in 2000 to nearly 400 million barrels in 2014 (NDIC 2015). The number of wells producing oil increased from approximately 3,300 to 12,500 in the same 14-year period (NDIC 2015). Both the decline in grassland habitat and increased anthropogenic disturbance can have negative impacts on bird populations.

In agricultural areas, Greater Prairie-Chickens (*Tympanuchus cupido*) had lower nest success in pasture and hayland habitats and in areas with greater habitat fragmentation (Ryan et al. 1998). Thompson et al. (2015) found avoidance of infrastructure associated with gas and oil development by grassland songbirds from 150 m up to 267 m in North Dakota. Increased use of roads in areas of heavy gas and oil development have been shown to change the vegetation community surrounding

roadways and altering bird communities (Ingelfinger and Anderson 2004). During winter months, female Greater-Sage Grouse (*Centrocercus urophasianus*) avoided areas of suitable sage-brush habitat that contained oil wells in the Powder River Basin in Wyoming and Montana (Doherty et al. 2008). Pitman et al. (2005) found greater avoidance in Lesser Prairie-Chicken (*Tympanuchus pallidicinctus*) nest site selection relative to anthropogenic features when nesting in grassland rather than sage-sandbrush habitat in Kansas. Burr (2014) found indirect influences of energy development on Sharp-tailed Grouse (*Tympanuchus phasianellus*) nest success. Areas of intense gas and oil development had fewer nest predators and higher nest success than areas of less intense development (Burr 2014).

Most studies evaluating the influence of gas and oil development on upland gamebird species focus on Greater Sage-Grouse and Lesser Prairie-Chickens (Hovick et al. 2014). In 2011, North Dakota Game and Fish recognized deficiencies in knowledge of the impact of increasing oil development on the state's wildlife populations (Dyke et al. 2011). In response, they created a document that identified wildlife species that may be impacted by energy development, plans for evaluating impacts, and ways to mitigate disturbances (Dyke et al. 2011). One of the species they identified as "at risk" was the Sharp-tailed Grouse.

Sharp-tailed Grouse (hereafter "sharptail" or "sharptails") are an upland nesting gamebird found throughout the grassland of North Dakota. The Plains subspecies (*T. p. jamesi*), found in western North Dakota, is thought to be doing the best of the six subspecies because of their utilization of row crops for forage during the fall and winter (Connelly 1998, Johnsgard 2008). Although North Dakota sharptails are thought to be



doing well, little is known about factors influencing population dynamics, especially given the changes in land use and landscape characteristics in recent years.

Nest attendance, or how incubating parents spend time on the nest, is an important component of reproductive ecology (Trivers 1972). Patterns in nest attendance can be one of the first indications of stress for incubating birds, often before we see changes in nest success or population level changes. Stresses can include those associated with food availability, proximity, and quality (Afton 1980, Ankney and Afton 1988, Bókony et al. 2009). These stresses can have consequences on fitness, resulting in tradeoffs in time allocation made by the incubating parent to self-maintenance and attendance at the nest.

This time allocation tradeoff can be examined through three related parameters: number of recess events, duration of recess events, or overall incubation constancy. The *number of daily recesses* is defined as how often hens leave the nest to engage in self-maintenance activities during one day. *Average daily recess duration* is how the hen is gone during each recess. Finally, *incubation constancy*, or how much time hens spend incubating during a 24-hour period which represents parental investment in the clutch. Thus, patterns that result in less time spent attending the nest may indicate a decreased investment in the nest, suggesting greater priority on the hen surviving to the next year to reproduce (Stuch 1962). The objective of this study was to classify nest attendance patterns of western North Dakota sharptails relative to characteristics of the landscape, hen, and nest using miniature surveillance cameras.

## Methods

### *Study Area*

As part of a larger study on sharptail ecology, we monitored nests at two study sites in Mountrail County, North Dakota, between March and August of 2012 and 2013. Belden (centroid location: N: 48.087094 W: -102.408549; area: 147.2 km<sup>2</sup>) and Blaisdell (centroid location: N: 48.269953 W: -102.086157; area: 158.3 km<sup>2</sup>) are primarily comprised of rolling hills, buttes, draws, and small wetlands. Based on reclassified U. S. Department of Agriculture National Landcover Dataset (Table 1) grassland was the predominant cover type at both Blaisdell and Belden (54% and 68%, respectively). Crops accounted for 22% of land at Belden and 37% at Blaisdell, with each containing approximately 2% fallow land. Wetlands were found across 5% of Blaisdell and 2% of Belden. Both sites had few trees and shrubs (Belden 4% and Blaisdell < 1%). These sites lie on the eastern edge of oil development within Mountrail County and vary in intensity of energy development. Blaisdell, our site of “low” intensity, had a maximum well density of 0.006 wells/km<sup>2</sup> during 2013 (Burr 2014). Belden, our site of “high” oil and gas development, had an increase of 0.183 wells/km<sup>2</sup> between 2012 and 2013 resulting in a maximum well density of 0.950 wells/km<sup>2</sup> (Burr 2014). Percent developed land (e.g., roads, towns, large farm operations, and towns) was approximately 3% at both Belden and Blaisdell.

### *Field Methods*

Sharptail hens were trapped at leks using walk-in style traps from March through mid-May during the springs of 2012 and 2013. Upon capture we aged (i.e. juvenile or adult), weighed, and fitted hens with a metal leg band and either a 10.7 g or 16 g

necklace-style radio collar. Between mid-May and July we monitored hen locations using hand-held, truck-mounted, and aerial telemetry to find nest locations. Upon discovery of the nest, we recorded clutch size, nest attempt within the season, GPS location (Geographic Coordinate System: North America 1983; Datum: North American Datum 1983 UTM Zone 14), and location relative to other landmarks. We used hen age as our only hen characteristic covariate (Table 1). Nest characteristic covariates included nest attempt, maximum clutch size, and nest fate (Table 1).

At a subset of nests, a 24 hour infrared surveillance camera was installed 0.25 – 0.5 m from the nest. There were three components to the camera system: surveillance camera, camera box, and battery. The surveillance camera was equipped with light emitting diodes (LEDs) for night vision capabilities. Cameras were attached to a 0.6 m piece of steel rebar staked into the ground. The camera box housed a digital video recorder (DVR), and was attached to the camera with cable, and located at least 25 m from the nest. Video was recorded continuously onto 32 gigabyte secure digital (SD) cards at high resolution at 10 frames per second. Date and military time were set upon camera installation. The DVR and camera were powered using a 12-volt 35-amp battery located next to the camera box. We camouflaged all components with paint and surrounding vegetation, and attempts were made to minimize scent and vegetation disturbance around and leading up to the nest.

Batteries and SD cards were changed every 3 to 4 days. We also checked for the presence of the incubating hen during these times with a portable Tote Vision LCD monitor and telemetry. If the hen was not present, we approached the nest to determine if it was destroyed, hatched, or the hen was on recess. In the event that the nest had hatched

or been destroyed, we removed the camera and verified fate by reviewing video footage. Cameras were relocated to another active nest if available.

### *Video Analysis*

We watched video beginning at midnight of the day after installation until the day of nest fate. We specifically watched for nest recesses. We characterize these as any time the hen is not tending her eggs, but rather performing self-maintenance activities such as foraging. These recesses do not include times when the hen was flushed off the nest by a researcher, predator, or non-predator animal. Recess start and stop times, characterized by the hen leaving the nest bowl and then returning to sit down on the nest, along with day were recorded. From this information we were able to derive our three metrics for nest attendance: *daily number of recesses*, *average daily recess duration*, and *incubation constancy*.

### *Land Cover Analysis*

To evaluate the influence of land cover we took a two-step approach first by identifying important land cover covariates, then by identifying the appropriate scales to model those covariates. To begin we reclassified land cover data for 2012 and 2013 using ArcMap 10.1.3 (Environmental Systems Research Institute, Redlands, CA) from National Agriculture Statistics Service products (USDA 2014). We created five broad categories: crops, grassland, trees/shrubs, water/wetland, fallow (i.e., areas with idle cropland and bare ground), and developed (Table 2). To ensure correct assignment of land cover, we performed an accuracy assessment in ERDAS Imagine 2014 (Hexagon Geospatial, Madison, AL) using 2012 and 2013 National Agricultural Inventory Program (NAIP) imagery for reference. All Kappa values exceeded 0.80 suggesting land cover

reclassification was accurate for our purposes of evaluating broad land-use categories (Congalton and Green 2009).

We decided to assess the percent cover of three land cover classes: grassland fallow, and developed areas (Table 1). Grassland primarily consisted of pasture (Table 2) and provides important cover and forage (Connelly 1998). Areas with fallow/idle cropland and bare ground were classified as fallow (Table 2). Although oil wells were classified as bare ground, fallow/idle cropland constituted approximately 85% of this class. These areas support communities of “weeds” that produce large amounts of seed, an important component of sharptail diet during the spring and summer (Connelly 1998). Roads constituted most developed areas; however these also included farms, towns, and businesses (including manufacturing facilities). These areas act as disturbances that are avoided by both birds and mammals (Benítez-López et al. 2010). Initially we modeled percent grassland as a linear and quadratic function and found no difference in model performance; therefore, we modeled percent grassland as a quadratic function as we recognize that other landscape components (i.e. trees and shrubs) are important habitat and food sources for sharptails (Johnsgard 2008). We modeled percent developed and fallow as linear functions rather than a quadratic due to the limited range of values (Table 1). In addition to land cover variables, we calculated oil density within the five scales described below (wells/km<sup>2</sup>) based on well locations provided by the North Dakota Industrial Commission, Department of Mineral Resources, Oil and Gas Division as of August 2013.

Land cover compositions within a 50 m radius (microsite; scale associated with nest site selection), 437 m (local; area used by nesting prairie chickens), and 1600 m

(landscape scale; area used by hens during breeding season while not incubating) radius around the nest have been correlated to nest success (Manzer and Hannon 2005).

Although these three scales are commonly used in prairie grouse research, we explored the possibility other intermediate scales (250 m and 800 m) in between the scales discussed above. To determine the most appropriate scales (i.e. either 50 m, 250 m, 450 m, 800 m, or 1600 m) to model nest attendance we generated 6 land cover combinations of % grassland<sup>2</sup>, % fallow, and % developed land. For each combination we made models of incubation constancy for the given combination for each scale. For example, we made 5 models that contained % grassland<sup>2</sup> + % developed at 50 m, 250 m, 450 m, 800 m, and 1600m (Table 3). To evaluate which scales performed the best for each land cover combination we used multi-model inference and ranked models by lowest AIC<sub>c</sub> and model weights ( $w_i$ ) (Burnham and Anderson 2002). We used the PROC MIXED procedure in SAS to run models (Table 3). We found that 250 m, 450 m, and 800 m models ranked in the top three models for more than 5 land cover combinations (Table 3); therefore, we selected these three scales for our analysis.

Sharptail nest locations tend to be clustered around leks; therefore, we tested for spatial autocorrelation by evaluating Moran's I values generated in SAM (Spatial Analysis in Macroecology) (Rangel et al. 2010) for average incubation constancy, average recess duration, and average number of recesses for each bird. We found no spatial autocorrelation between nests (all Moran's I p-values > 0.05), allowing us to continue with our analysis without the inclusion of any spatial adjustments to account for dependence among nests.

In addition, we calculated distance to nearest well (m) and binned these distances into three classes: 0–450 m, 451–1600 m, and > 1600 m. We chose to categorized distance to nearest well because of the large variation in distances between Belden and Blaisdell influenced model performance, with average distance to nearest well averaging 722.16 m in Belden (min = 150.43 m, max = 1571.22 m; only 2 nests within 250 m of a well), and 3,638.55 m in Blaisdell (min = 564.21 m, max = 6742.54 m) (Burr 2014).

### *Data Analysis*

We used two-tailed t-tests to compare percent grassland<sup>2</sup>, fallow, and developed land at 250 m, 450 m, and 800m from the nest between Belden and Blaisdell. We did this with the T.TEST function in Microsoft Excel 2010 (Microsoft Corporation, Redmond, WA) and a two-sample unequal variance test. This function produced p-values for us to evaluate if differences between sites are statistically significant. In addition we calculated means and standard deviations for each land cover covariate at Belden and Blaisdell.

We summarized patterns in number of recesses by calculating means for all nests and by year and site. In addition, we plotted start time of recesses to characterize time of day for recesses. To evaluate incubation constancy and average daily recess duration we generated 36 models. Due to correlation of land cover between spatial extents (i.e. percent grass at 250 m was highly correlated with percent grass at 450 m and 800 m) we did not mix spatial extents (Ellis-Felege 2010). We ran our models using PROC MIXED (Coates and Delehanty 2008, Burnam et al. 2012) in SAS (SAS Institute 2003). We constructed models that we felt *a priori* held biological significance rather than using all combinations. We evaluated models based on lowest AIC<sub>c</sub> and model weight ( $w_i$ )

(Burnham and Anderson 2002). To assess the influence of each covariate we calculated model averaged estimates and evaluated statistical significance based on the exclusion of 0 from 95% confidence intervals and magnitude of effect by examining  $\beta$ -estimates (Burnham and Anderson 2002).

## **Results**

### *Land Cover Differences Between Sites*

In general we found grass to be the predominant land cover type near nests at all distances and at both Belden and Blaisdell (Table 4). We observed there to be more grass near nests at Blaisdell compared to Belden (Table 4). Belden had greater proportions of fallow and developed land (with the exception of percent developed land at 800 m which was similar between sites) (Table 4). We found percent developed land at 450 m to be the only statistically significant ( $p$ -value  $\leq 0.05$ ) covariate that differed between Belden and Blaisdell; however, percent fallow land at 800 m had a  $p$ -value of 0.06 suggesting that this too maybe a notable difference between sites (Table 4).

### *Nest Attendance*

We monitored a total of 90 nests with cameras. Of those, we viewed 55 nests for this analysis, equating to 444 nest-days and over 10,650 hours of footage. From this data we observed 1,115 recess events. Our hens were 54.5% adult and had an average clutch size of 12.6 eggs (SD = 2.04). Most of the nests we viewed were first attempts (78.2% of nests). Overall apparent nest success was 50.9%. Apparent nest success was higher during 2012 (57.6%,  $n = 33$  nests) than in 2013 (40.9%,  $n = 22$ ), and it was higher for nests at Belden (57.7%,  $n = 26$ ) than Blaisdell (44.8%,  $n = 29$ ). These estimates of nest success are comparable to those of a larger sample of 163 sharptail nests monitored both



with and without cameras (Belden = 62% successful, Blaisdell = 44% successful) (Burr 2014).

From our summary statistics, we found that hens took approximately 2 to 3 recesses per day (Table 5), once in the morning and once in the evening (Figure 4). We observed hens at Blaisdell to take more recesses on average than those at Belden, and hens in 2013 to take more than hens in 2012 (Table 5).

Average incubation constancy for all nests was 95.2% (approximately 22.8 hours/day) (Table 5). Hens in 2012 incubated longer than those in 2013. Belden hens incubated longer than their counterparts at Blaisdell. Models containing year and year and site accounted for 75% of model weights and had a  $\Delta AIC_c \leq 2.0$  (Table 6). Model-averaged estimates for these models revealed year as the only statistically significant covariate that accurately predicts incubation constancy (Table 7). We found that hens in 2013 incubated 1.7% *less* (approximately 24.5 minutes) than those in 2012.

Overall, hens took an average of 27.6 minutes for each recess (Table 5). Similar to incubation constancy, as is expected given the relationship of these metrics, Blaisdell hens average daily recess duration was 29.6 minutes or 3 minutes longer than hens at Belden (Table 5). During 2012, hens spent approximately 1 minute more on recess than those in 2013. Like incubation constancy, site and site and year along with the intercept only model accounted for 75% of model weights (Table 8). Unlike incubation constancy, no parameters were shown to be statistically significant in their ability to accurately predict patterns of average daily recess duration (Table 9).

## Discussion

Year was the only covariate that explained variation in any behavior. We hypothesize that hens spent more time on the nest during 2012 than 2013 because of differences in weather patterns. From January through March in Stanley, ND, average temperature was approximately 10°C cooler in 2013 compared to 2012 (NOAA 2013, NOAA 2014). Average precipitation during the same months was 4.8 cm greater in 2013 than 2012 (NOAA 2013, NOAA 2014). The combination of cooler temperatures and greater snowfall in 2013 may have decreased access to food resources or required more energy devoted to thermoregulation prior to the breeding season. To compensate for fewer energy reserves hens may have needed to spend more time foraging during incubation resulting in lower incubation constancy. Hens may also have needed to take more, shorter recesses during 2013 to maintain proper temperatures for egg development, an incubation pattern observed in Common Goldeneyes (*Bucephala clangula*) (Mallory and Weatherhead 1993). Although we observed differences in incubation constancy between the two years, Burr (2014) found no difference in nest survival. This suggests that observed differences we found in the amount of time spent on the nest does not influence nest fate; however, we still do not understand how nest attendance and hen condition influence brood success. Further research is needed to determine what nest attendance patterns optimize nest *and* brood success.

We did not observe any other statistically significant trends in nest attendance patterns. We did observe what we believe to be potentially biologically important differences between sites. Greater parental investment (i.e. greater incubation constancy, shorter recess duration, and fewer recesses) was observed at Blaisdell, our site of low gas

and oil intensity. We believe that one possible explanation for this pattern could be that Blaisdell hens could be in poorer body condition than those in Belden. Bukacińska and Bukacińska (1966) found that unsuccessful pairs of Herring Gulls (*Larus argentatus*) left to feed more frequently and for longer periods of time. In addition, Burr (2014) found higher nest predation at Blaisdell. An alternative explanation could be that we are observing a life-history tradeoff that is caused by stress induced by increased predation. McNew et al. (2011) found that sites with less human disturbance had lower nest and brood success but higher hen survival. This suggests that hens are increasing their probability of survival to the next breeding season at the expense of the current seasons reproduction (McNew et al. 2011). In addition to our observations of decrease parental investment at Blaisdell and Burr (2014) observations of higher predation rates at the site, we may be observing a shift of life-history traits similar to long-lived species (lower yearly reproductive output) supporting the hypothesis of McNew et al. (2011).

We did not observe any covariates other than year to explain variation of nest attendance patterns in any direction. It is possible that little variation in nest attendance patterns could be the result of hen condition at the onset of breeding. We predict that hens in high enough body condition to incubate exhibit similar nest attendance patterns whereas nests of hens in poor condition do not make it through the egg-laying stage and are not detected by our radio-telemetry methods that identify nests after incubation has started. An alternative explanation could be that landscape changes are not yet drastic enough to observe statistically different incubation patterns. Overall, there were only small differences in land-use between Belden and Blaisdell with both experiencing a variety of landscape disturbances; however, there were differences between sites and year

in oil well densities. It is possible that oil well density was not a good predictor because sharptails are avoiding these structures prior to incubation. We suspect some nest site selection to be occurring relative to proximity to oil wells, although formal nest site selection analysis were not conducted as part of this study. We, however, observed only 2 out of 55 nests (4%) to be within 250m of an oil well. Both of these nests were at Belden and during 2013 when oil well density increased from 0.183 wells/km<sup>2</sup> to 0.950 wells/km<sup>2</sup> (Burr 2014). Similar nest site avoidance of anthropogenic features from 144 m up to 1019 m has been observed in Lesser Prairie-Chickens in Kansas (Pitman et al. 2005). Energy development may not be so intense that it is forcing hens to nest in areas in close proximity to oil wells; therefore, we are not seeing influences of oil well density on nest attendance patterns. It is possible that nest site selection and nest attendance patterns will change in response to increased oil production in North Dakota with development of new extraction techniques (Fahey 2011). In addition, we also found a statistical difference in the percent developed land at 450 m, with Belden having more developed areas than Blaisdell. Developed areas were primarily roads; therefore, we suspect more roads create more disturbances which can alter nest predator behavior (Burr 2014).

Although we did not find the landscape to change incubation behaviors, it could cause changes in other aspects of their reproductive ecology. Burr (2014) found changes in nest success and nest predator community at large scales, with greater nest success and lower predator abundance being in areas of heavier energy development. To validate our hypothesis that nest success, predator abundance, and nest attendance are functions of

human development we need to determine hen survival. By doing this we can determine what factors drive the tradeoff between fitness of the hen and nest.

We need to determine how density of and distance to nearest anthropogenic feature influences nesting ecology. We used a coarse approach to classifying anthropogenic features. Future research using more specific classification of anthropogenic features (e.g., quantify road traffic, identify flaring wells, determine amount of noise at the nest, are features within line-of-sight from the nest, etc.) is needed to develop specific strategies for future land-use and landscape configuration in multi-use landscapes. In addition, we know little about the influence of gas and oil development on brood success for sharptails. In Greater Sage-Grouse brooding females were found to avoid producing wells; however, there was no relationship between energy development and brood success (Holloran 2005).

### **Management Implications**

As agriculture and the need for natural gas and oil increase there are several ways managers and biologists can help sharptails persist on the landscape. We can continue to work with landowners to manage multi-use grasslands to provide good habitat for sharptails throughout the year. By managing grasslands for sharptails and cattle production, we can provide optimal vegetation structure and composition for nest site selection (McNew et al. 2013), and habitat for cover and food during the winter (Connelly 1998). To mitigate the impact of gas and oil development, we can encourage energy companies to concentrate multiple jack-pumps to a single pad increasing the amount of usable land for sharptails. Thompson et al. (2015) found that grassland birds avoided multi-bore well pads at 150 m rather than 267 m at single bore-well pads.

Finally, future research questions should look to evaluate how energy development influences multiple aspects of life history traits to give a complete picture of how human disturbances alter population dynamics.

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## Tables

Table 1. Definitions for covariates used to evaluate nest attendance patterns. Abbreviations used in tables and figures.

Covariate	Abbreviations	Description	Range of Values
Year		2012* or 2013 field season.	
Site		Belden*: high intensity of gas and oil development.	
		Blaisdell: low intensity of gas and oil development.	
Age		Juvenile* or adult.	
Nest Attempt	attempt	Nest attempt within one year.	
Maximum Clutch Size	max_clutch	Maximum number of eggs found at the nest.	8 – 16 eggs
Nest Fate	fate	Successful or failed*.	
% Grassland <sup>2</sup> 250 m	G <sup>2</sup> 250	Percent grassland squared within 250 m of the nest.	4.48 – 100% <sup>2</sup>
% Grassland <sup>2</sup> 450 m	G <sup>2</sup> 450	Percent grassland squared within 450 m of the nest.	1.80 – 100% <sup>2</sup>
% Grassland <sup>2</sup> 800 m	G <sup>2</sup> 800	Percent grassland squared within 800 m of the nest.	<0.00 – 99.27% <sup>2</sup>

Table 1 cont.

<b>Covariate</b>	<b>Abbreviations</b>	<b>Description</b>	<b>Range of Values</b>
% Fallow 250 m	F250	Percent fallow land within 250 m of the nest.	0 – 68.24%
% Fallow 450 m	F450	Percent fallow land within 450 m of the nest.	0 – 25.66%
% Fallow 800 m	F800	Percent fallow land within 800 m of the nest.	0 – 14.93%
% Developed 250	D250	Percent developed land within 250 m of the nest.	0 – 14.71%
% Developed 450	D450	Percent developed land within 450 m of the nest.	0 – 24.97%
% Developed 800	D800	Percent developed land within 800 m of the nest.	0 – 26.56%
Well Density 450 m	WellD450	Density of oil wells within 450 m of the nest.	0 – 0.003 wells/km <sup>2</sup>
Well Density 800 m	WellD800	Density of oil wells within 800 m of the nest.	0 – 0.004 wells/km <sup>2</sup>
Nearest Well < 450 m	NWell450	Nearest well is within 450 m of the nest.*	
Nearest Well 450 – 1600 m	NWell450_1600	Nearest well is between 450 m and 1600 m of the nest.	
Nearest Well >1600 m	NWell1600	Nearest well is beyond 1600 m of the nest.	

\*Baseline for comparison.

Table 2. Land cover reclassification scheme. Percent contribution of NASS classification to reclassified category and landscape are also included.

Reclassified Categories	NASS Classification	2012		2013	
		% of Category	% of Landscape	% of Category	% of Landscape
<i>Grassland</i>	Grassland/Pasture	94.6%	43.3%	94.6%	45.4%
	Other Hay/Non Alfalfa	4.0%	1.8%	4.0%	1.9%
	Alfalfa	1.4%	0.6%	1.4%	0.7%
	Clover/Wildflowers	< 0.1%	< 0.1%	< 0.1%	< 0.1%
	Sod/Grass Seed	< 0.1%	< 0.1%	< 0.1%	< 0.1%
	<i>Total</i>			45.8%	48.0%
<i>Cropland</i>	Spring Wheat	29.4%	11.1%	37.5%	13.1%
	Durum Wheat	26.4%	10.0%	14.8%	5.1%
	Canola	15.9%	6.0%	16.7%	5.8%
	Peas	6.8%	2.6%	13.3%	4.6%
	Flaxseed	6.1%	2.3%	4.0%	1.4%

Table 2 cont.

<b>Reclassified Categories</b>	<b>NASS Classification</b>	<b>2012</b>		<b>2013</b>	
		<b>% of Category</b>	<b>% of Landscape</b>	<b>% of Category</b>	<b>% of Landscape</b>
<i>Cropland</i>	Winter Wheat	5.7%	2.2%	1.2%	0.4%
	Barley	4.2%	1.6%	3.8%	1.3%
	Sunflower	2.4%	0.9%	2.3%	0.8%
	Corn	1.2%	0.5%	3.0%	1.0%
	Lentils	0.8%	0.3%	0.8%	0.3%
	Soybeans	0.5%	0.2%	1.4%	0.5%
	Dry Beans	0.3%	0.1%	0.2%	0.1%
	Rye	NA	NA	< 0.1%	< 0.1%
	Oats	0.2%	0.1%	0.6%	0.2%
	Mustard	0.2%	0.1%	0.2%	0.1%
	Buckwheat	< 0.1%	< 0.1%	< 0.1%	< 0.1%
	Millet	< 0.1%	< 0.1%	0.1%	< 0.1%

Table 2 cont.

<b>Reclassified</b>	<b>NASS</b>	<b>2012</b>		<b>2013</b>		
		<b>Categories</b>	<b>Classification</b>	<b>% of Category</b>	<b>% of Landscape</b>	<b>% of Category</b>
<i>Cropland</i>	Safflower		< 0.1%	< 0.1%	0.1%	0.1%
	Potatoes		< 0.1%	< 0.1%	< 0.1%	< 0.1%
	Sorghum		< 0.1%	< 0.1%	< 0.1%	< 0.1%
	Sugarbeets		< 0.1%	< 0.1%	< 0.1%	< 0.1%
	Triticale		< 0.1%	< 0.1%	< 0.1%	< 0.1%
	Dbl Crop Barley/Sorghum	NA	NA	NA	< 0.1%	< 0.1%
	Radishes		< 0.1%	< 0.1%	< 0.1%	< 0.1%
	<i>Total</i>			<i>37.8%</i>		<i>34.8%</i>
<i>Water/Wetlands</i>	Open Water		74.3%	6.1%	74.3%	6.4%
	Herbaceous Wetlands		23.0%	1.9%	23.0%	2.0%



Table 2 cont.

<b>Reclassified Categories</b>	<b>NASS Classification</b>	<b>2012</b>		<b>2013</b>	
		<b>% of Category</b>	<b>% of Landscape</b>	<b>% of Category</b>	<b>% of Landscape</b>
<i>Water/Wetlands</i>	Woody Wetlands	2.7%	0.2%	2.7%	0.2%
	<i>Total</i>		8.2%		8.6%
<i>Developed</i>	Developed/Open Space	90.8%	3.1%	90.8%	3.3%
	Developed/Low Intensity	8.6%	0.3%	8.6%	0.3%
	Developed/Med Intensity	0.5%	< 0.1%	0.5%	< 0.1%
	Developed/High Intensity	0.1%	< 0.1%	0.1%	< 0.1%
	<i>Total</i>		3.4%		3.6%
<i>Trees/Shrubs</i>	Deciduous Forest	93.4%	2.9%	93.4%	3.0%
	Shrubland	5.4%	0.2%	5.4%	0.2%
	Mixed Forest	0.6%	< 0.1%	0.6%	< 0.1%

Table 2 cont.

<b>Reclassified Categories</b>	<b>NASS Classification</b>	<b>2012</b>		<b>2013</b>	
		<b>% of Category</b>	<b>% of Landscape</b>	<b>% of Category</b>	<b>% of Landscape</b>
<i>Trees/Shrubs</i>	Evergreen Forest	0.6%	< 0.1%	0.6%	< 0.1%
	<i>Total</i>		<i>3.1%</i>		<i>3.3%</i>
<i>Fallow</i>	Fallow/Idle Cropland	85.8%	1.4%	85.8%	1.5%
	Barren	14.2%	0.2%	14.2%	0.2%
	<i>Total</i>		<i>1.6%</i>		<i>1.7%</i>

Table 3. Selection for spatial scale test by modeling incubation constancy relative to grassland<sup>2</sup>, developed, and fallow land at 50 m, 450 m, 800 m, and 1600 m in SAS using PROC MIXED.  $\Delta AIC_c$  and  $w_i$  were calculated within a single model family.

<b>Model</b>	<b>AIC<sub>c</sub></b>	<b><math>\Delta AIC_c</math></b>	<b><math>w_i</math></b>	<b>Deviance</b>
<i>Grassland<sup>2</sup> + Developed + Fallow</i>				
450 m	-1308.30	0.00	0.74	-1320.53
800 m	-1305.40	2.90	0.17	-1317.57
250 m	-1302.90	5.40	0.05	-1315.12
1600 m	-1302.30	6.00	0.04	-1314.25
<i>Grassland<sup>2</sup> + Developed</i>				
450 m	-1310.10	0.00	0.73	-1320.28
800 m	-1306.80	3.30	0.14	-1316.91
250 m	-1304.70	5.40	0.05	-1314.85
1600 m	-1304.40	5.70	0.04	-1314.52
50 m	-1304.10	6.00	0.04	-1314.28
<i>Grassland<sup>2</sup> + Fallow</i>				
450 m	-1301.00	0.00	0.72	-1320.17
800 m	-1307.40	2.60	0.20	-1317.56
250 m	-1304.50	5.50	0.05	-1314.64
1600 m	-1304.40	5.60	0.04	-1314.52

Table 3 cont.

<b>Model</b>	<b>AIC<sub>c</sub></b>	<b><math>\Delta</math>AIC<sub>c</sub></b>	<b><math>w_i</math></b>	<b>Deviance</b>
<i>Grassland<sup>2</sup></i>				
450 m	-1311.80	0.00	0.71	-1319.92
800 m	-1308.80	3.00	0.16	-1316.89
1600 m	-1306.40	5.40	0.05	-1314.52
250 m	-1306.20	5.60	0.04	-1314.25
50 m	-1306.10	5.70	0.04	-1314.21
<i>Developed</i>				
450 m	-1308.10	0.00	0.39	-1316.23
250 m	-1306.50	1.60	0.17	-1314.54
50 m	-1306.20	1.90	0.15	-1314.25
800 m	-1306.10	2.00	0.14	-1314.23
1600 m	-1306.10	2.00	0.14	-1314.19
<i>Fallow</i>				
450 m	-1310.00	0.00	0.34	-1315.63
800 m	-1307.40	0.30	0.29	-1315.30
250 m	-1304.50	1.00	0.20	-1314.64
1600 m	-1304.40	1.40	0.17	-1314.23

Table 4. Land cover composition differences within 250 m, 450 m, and 800 m of nests at Belden and Blaisdell. P-values generated from two-tailed, unequal variance, t-tests in Microsoft Excel. Bolded covariates are those that differ significantly ( $p \leq 0.05$ ) between Belden and Blaisdell.

Covariate	p-value	Belden		Blaisdell	
		Mean	SD	Mean	SD
G <sup>2</sup> 250	0.11	0.69	0.29	0.81	0.25
D250	0.39	0.04	0.04	0.03	0.04
F250	0.23	0.04	0.13	0.00	0.01
G <sup>2</sup> 450	0.28	0.56	0.28	0.65	0.32
<b>D450</b>	<b>0.04</b>	<b>0.05</b>	<b>0.06</b>	<b>0.03</b>	<b>0.03</b>
F450	0.35	0.03	0.06	0.01	0.05
G <sup>2</sup> 800	0.58	0.42	0.23	0.46	0.31
D800	0.92	0.03	0.02	0.03	0.05
F800	0.06	0.03	0.04	0.01	0.03

Table 5. Summary statistics for incubation constancy, average daily recess duration, and number of recesses for all nests, and by year and site.

	<b>Belden</b>	<b>Blaisdell</b>	<b>2012</b>	<b>2013</b>	<b>All Nests</b>
<i>Number of Daily Recesses</i>					
Mean	2.3	2.9	2.4	2.6	2.5
SD	0.9	1.3	1.2	1.1	1.2
Min	1	0	0	0	0
Max	9	8	9	8	9
<i>Average Daily Recess Duration (minutes)</i>					
Mean	26.6	29.6	28.1	27.2	27.6
SD	14.3	34.0	28.8	16.7	23.5
Min	5.1	0.0	0.0	5.1	0.0
Max	95.4	332.6	332.6	91.5	332.6
<i>Incubation Constancy (percent of 24-hr day)</i>					
Mean	95.7	94.0	95.2	95.1	95.2
SD	2.1	4.9	3.8	2.8	3.3
Min	85.0	53.8	53.8	77.8	53.8
Max	99.1	100.0	100.0	100.0	100.0

Table 6. Model selection results for correlation between incubation constancy and characteristics of the hen, nest, and landscape. Models generated and run in SAS using PROC MIXED, ranked by lowest AIC<sub>c</sub> from 55 Sharp-tailed Grouse nests. Covariate abbreviations explained in Table 1.

<b>Model</b>	<b>AIC<sub>c</sub></b>	<b>ΔAIC<sub>c</sub></b>	<b>w<sub>i</sub></b>	<b>K</b>	<b>Deviance</b>
year	-1316.6	0.00	0.442	2	-1324.68
site + year	-1315.9	0.70	0.311	3	-1326.01
attempt + max_clutch + fate + G <sup>2</sup> 450 + F450	-1312.6	4.00	0.060	6	-1328.95
attempt + max_clutch + fate	-1311.5	5.10	0.035	4	-1323.65
attempt + max_clutch + fate + age	-1311.1	5.50	0.028	5	-1325.36
attempt + max_clutch + fate + G <sup>2</sup> 450 + D450 + WellD450	-1310.7	5.90	0.023	7	-1329.13
attempt + max_clutch + fate + G <sup>2</sup> 800 + F800	-1309.7	6.90	0.014	6	-1326.01
attempt + max_clutch + fate + D250	-1309.5	7.10	0.013	5	-1323.79
attempt + max_clutch + fate + D450	-1308.5	8.10	0.008	6	-1324.88
intercept only	-1308.1	8.50	0.006	1	-1314.18
attempt + max_clutch + fate + G <sup>2</sup> 250 + F250	-1308.1	8.50	0.006	6	-1324.41
age + G <sup>2</sup> 450 + F450	-1308.1	8.50	0.006	3	-1320.26
NWell450_1600 + NWell1600 + max_clutch + attempt + fate	-1307.8	8.80	0.005	6	-1324.16

Table 6 cont.

<b>Model</b>	<b>AIC<sub>c</sub></b>	<b>ΔAIC<sub>c</sub></b>	<b>w<sub>i</sub></b>	<b>K</b>	<b>Deviance</b>
NWell450_1600 + NWell1600 + max_clutch + attempt + fate + age	-1307.6	9.00	0.005	7	-1325.98
attempt + max_clutch + fate + G <sup>2</sup> 250 + D250	-1307.5	9.10	0.005	6	-1323.87
attempt + max_clutch + fate + D800	-1307.4	9.20	0.004	6	-1323.71
attempt + max_clutch + fate + age + G <sup>2</sup> 450 + D450 + F450	-1307.3	9.30	0.004	9	-1329.88
age + G <sup>2</sup> 450 + D450 + WellID 450	-1307.3	9.30	0.004	4	-1321.58
site	-1306.8	9.80	0.003	2	-1314.91
age	-1306.6	10.00	0.003	2	-1314.69
attempt + max_clutch + fate + G <sup>2</sup> 800 + D800 + WellID 800	-1306.6	10.00	0.003	7	-1325.06
age + G <sup>2</sup> 800 + F800	-1305.7	10.90	0.002	4	-1317.88
attempt + max_clutch + fate + age + G <sup>2</sup> 250 + D250 + F250	-1305.5	11.10	0.002	8	-1326.05
age + D450 + WellID 450	-1305.4	11.30	0.002	4	-1317.63
attempt + max_clutch + fate + age + G <sup>2</sup> 800 + D800 + F800	-1305.3	11.50	0.001	9	-1327.87
age + D250	-1305.1	12.20	0.001	3	-1315.25
NWell450_1600 + NWell1600	-1304.4	13.00	0.001	3	-1314.53
age + G <sup>2</sup> 250 + D250	-1303.3	13.30	0.001	4	-1315.45



Table 6 cont.

<b>Model</b>	<b>AIC<sub>c</sub></b>	<b><math>\Delta</math>AIC<sub>c</sub></b>	<b><math>w_i</math></b>	<b>K</b>	<b>Deviance</b>
NWell450_1600 + NWell1600 + age	-1302.9	13.70	0.000	4	-1315.06
age + G <sup>2</sup> 250 + F250	-1302.9	13.70	0.000	4	-1315.09
age + G <sup>2</sup> 800 + D800 + WellD 800	-1302.9	13.70	0.000	5	-1317.12
age + D800 + WellD 800	-1302.6	14.00	0.000	4	-1314.75

Table 7. Model-averaged beta ( $\beta$ ) estimates for covariates used to model incubation constancy relative to characteristics of the landscape, hen and nest. Bolded covariates are considered statistically significant ( $\beta$  LCI and UCI do not include 0). Abbreviations explained in Table 1.

Parameter	Estimate	SE	LCI	UCI
intercept	0.936	0.027	0.088	0.989
<b>year</b>	<b>-0.017</b>	<b>0.006</b>	<b>-0.030</b>	<b>-0.004</b>
site	-0.002	0.002	-0.007	0.003
attempt	0.000	0.002	-0.003	0.004
max_clutch	0.001	0.007	-0.001	0.002
fate	0.002	0.002	-0.002	0.006
age	0.000	4.945E-04	-0.001	0.001
NWell450_1600	0.000	1.190E-04	-2.146E-04	2.520E-04
NWell1600	-5.000E-05	1.269E-04	-2.972E-04	2.000E-04
G <sup>2</sup> 250	-2.000E-04	1.828E-04	-3.806E-04	3.360E-04
D250	3.900E-04	0.002	-0.003	0.004
F250	2.700E-04	4.441E-04	-0.001	0.001
G <sup>2</sup> 450	-0.002	0.002	-0.007	0.002
D450	0.001	0.003	-0.005	0.007
F450	0.002	0.004	-0.006	0.010
WellD450	-0.101	0.201	-0.496	0.293
G <sup>2</sup> 800	-2.800E-04	0.001	-0.001	4.650E-04
D800	-1.300E-04	0.001	-0.002	0.001

Table 7 cont.

<b>Parameter</b>	<b>Estimate</b>	<b>SE</b>	<b>LCI</b>	<b>UCI</b>
F800	0.001	0.003	-0.005	0.008
WellD800	-0.007	0.041	-0.088	0.074

Table 8. Model selection results for correlation between average daily recess duration and characteristics of the hen, nest, and landscape. Models generated and run in SAS using PROC MIXED, ranked by lowest  $AIC_c$  from 55 Sharp-tailed Grouse nests. Covariate abbreviations explained in Table 1.

<b>Model</b>	<b><math>AIC_c</math></b>	<b><math>\Delta AIC_c</math></b>	<b><math>w_i</math></b>	<b>K</b>	<b>Deviance</b>
year	4491.9	0.00	0.442	2	4483.81
site + year	4493.6	1.70	0.189	3	4483.46
intercept only	4494.6	2.70	0.115	1	4488.52
age	4496.2	4.30	0.051	2	4488.14
site + year	4496.5	4.60	0.044	2	4488.38
age + D250	4498.2	6.30	0.019	3	4488.08
attempt + max_clutch + fate	4498.5	6.60	0.016	4	4486.34
NWell450_1600 + NWell1600	4498.6	6.70	0.016	3	4488.46
age + D450 + WellD450	4499.2	7.30	0.011	4	4487.03
age + G <sup>2</sup> 250 + M250	4499.6	7.70	0.009	4	4487.4
age + G <sup>2</sup> 250 + D250	4499.6	7.70	0.009	4	4487.41
age + G <sup>2</sup> 450 + M450	4499.7	7.80	0.009	4	4487.54
age + D800 + WellD 450	4499.7	7.80	0.009	4	4487.51
attempt + max_clutch + fate + age	4499.8	7.90	0.009	5	4485.58
age + G <sup>2</sup> 800 + M800	4499.9	8.00	0.008	4	4487.73
NWell450_1600 + NWell1600 + age	4500.3	8.40	0.007	4	4488.06
attempt + max_clutch + fate + D250	4500.5	8.60	0.006	5	4486.27
age + G <sup>2</sup> 450 + d450 + WellD 450	4501.2	9.30	0.004	5	4486.92

Table 8 cont.

<b>Model</b>	<b>AIC<sub>c</sub></b>	<b>ΔAIC<sub>c</sub></b>	<b>w<sub>i</sub></b>	<b>K</b>	<b>Deviance</b>
age + G <sup>2</sup> 800 + d800 + WellID 800	4501.7	9.80	0.003	5	4487.45
attempt + max_clutch + fate + G <sup>2</sup> 250 + D250	4501.8	9.90	0.003	6	4485.44
attempt + max_clutch + fate + D450	4502	10.10	0.003	6	4485.66
attempt + max_clutch + fate + G <sup>2</sup> 250 + M250	4502.1	10.20	0.003	6	4485.82
attempt + max_clutch + fate + D800	4502.1	10.20	0.003	6	4485.72
attempt + max_clutch + fate + G <sup>2</sup> 450 + M450	4502.2	10.30	0.003	6	4485.9
attempt + max_clutch + fate + G <sup>2</sup> 800 + M800	4502.3	10.40	0.002	6	4485.96
NWell450_1600 + NWell1600 + max_clutch + attempt + fate	4502.5	10.60	0.002	6	4486.17
NWell450_1600 + NWell1600 + max_clutch + attempt + fate + age	4503.8	11.90	0.001	7	4485.34
attempt + max_clutch + fate + G <sup>2</sup> 450 + D450 + WellID 450	4504	12.10	0.001	7	4485.59
attempt + max_clutch + fate + G <sup>2</sup> 800 + D800 + WellID 800	4504.1	12.20	0.001	7	4485.72
attempt + max_clutch + fate + age + G <sup>2</sup> 250 + D250 + M250	4504.8	12.90	0.001	8	4484.24

Table 8 cont.

<b>Model</b>	<b>AIC<sub>c</sub></b>	<b>ΔAIC<sub>c</sub></b>	<b>w<sub>i</sub></b>	<b>K</b>	<b>Deviance</b>
attempt + max_clutch + fate + age + G <sup>2</sup> 800 + D800 + M800	4507.2	15.30	0.000	9	4484.58
attempt + max_clutch + fate + age + G <sup>2</sup> 450 + D450 + M450	4507.5	15.60	0.000	9	4484.87

Table 9. Model-averaged beta ( $\beta$ ) estimates for covariates used to model average recess duration relative to characteristics of the landscape, hen and nest. Abbreviations explained in Table 1.

<b>Parameter</b>	<b>Estimate</b>	<b>SE</b>	<b>LCI</b>	<b>UCI</b>
intercept	29.246	4.401	20.621	37.871
year	5.750	3.271	-0.662	12.161
site	0.476	0.939	-1.364	2.316
attempt	0.020	0.279	-0.526	0.566
max_clutch	-0.075	0.092	-0.254	0.105
fate	-0.054	0.234	-0.512	0.404
age	0.351	0.617	-0.858	1.559
NWell450_1600	-0.021	0.149	-0.313	0.271
NWell1600	0.009	0.152	-0.289	0.307
G <sup>2</sup> 250	-0.156	0.245	-0.637	0.325
D250	-0.028	1.837	-3.628	3.571
F250	0.039	0.345	-0.637	0.714
G <sup>2</sup> 450	0.050	0.131	-0.206	0.306
D450	-0.701	1.012	-2.685	1.283
F450	-0.080	0.412	-0.888	0.728
WellD450	0.015	0.081	-0.144	0.173
G <sup>2</sup> 800	0.013	0.119	-0.219	0.246
D800	-0.483	0.773	-1.997	1.032
F800	-0.309	0.589	-1.462	0.845
WellD800	-0.005	0.024	-0.052	0.042

## Figures

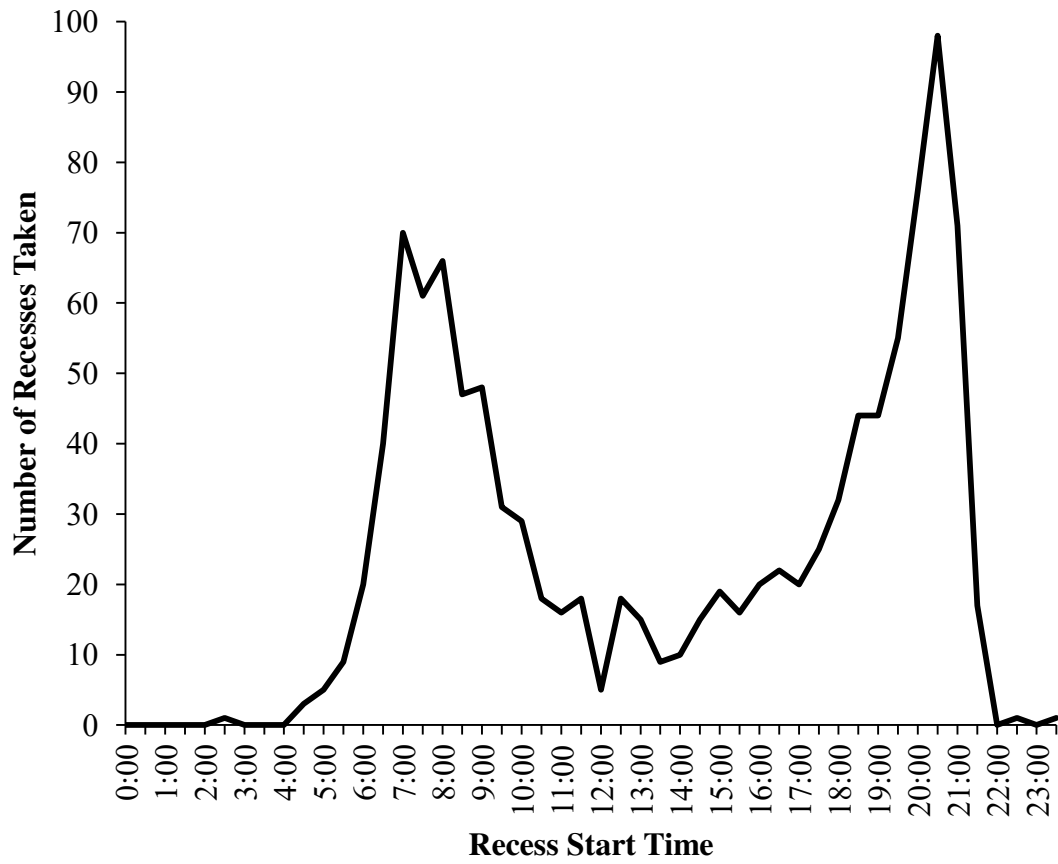


Figure 4. Timing of 1,115 recess events of Sharp-tailed Grouse in western North Dakota.



### **CHAPTER III**

#### **EVALUATING RESEARCH METHOD BIAS: IMPACT OF BEHAVIORS ASSOCIATED WITH NEST CAMERA INSTALLATION ON INCUBATING SHARP-TAILED GROUSE NEST SUCCESS**

##### **Abstract**

Use of cameras for avian nest monitoring can help us understand nest predator and parental behavioral responses to land-use changes. Although a popular tool, little is understood about the impact of cameras on bird behaviors. Few assess changes in daily nest attendance patterns or interactions with cameras. The objectives of this study were to (1) evaluate how nesting behaviors of female Sharp-tailed Grouse (*Tympanuchus phasianellus*) within the first 24 hours after camera installation influence daily nest survival rates (DSR), (2) to determine how various nest monitoring activities influence nest attendance patterns. We installed 24-hour infrared surveillance cameras and reviewed video for 96 nests during the summers of 2012 and 2013 in western North Dakota. We calculated summary statistics for behaviors within 24 hours of installation and modeled DSR relative to behaviors. We used a repeated measures approach to evaluate how incubation constancy changes with various nest monitoring activities. Within 24 hours of camera installation hens took two recesses, and incubated approximately 89% of the day, which is significantly less than days without research activity ( $P = <0.01$ ). Hens that sit next to the nest were 3.09 times less likely to succeed

than those that return directly to incubation. No other behaviors influenced nest success. Most behavioral responses to cameras were minimal suggesting they continue to be a valuable tool for studying avian nesting ecology.

### **Introduction**

Cameras have been a valuable tool for wildlife monitoring since their first use in the mid-1950s. Since that time camera, digital video recorder (DVR) and power technologies have drastically improved to provide higher camera resolution and overall quality, all while extending battery life (Cox et al. 2012) and becoming more affordable. The combination of these advancements has resulted in numerous camera studies with larger sample sizes and higher video quality on a wide array of species occupying various habitats. Greater accessibility has even led to citizen science based projects where volunteers stream video of bird nests and feeders (Desell et al. 2012, Cornell University 2015).

Cameras deployed at bird nests have become popular for studying nesting ecology, specifically in the areas of predator identification, parental investment, and nestling behavior (Cox et al. 2012). By being able to observe nest events, biologists can focus management efforts to improve nest and/or nestling success. However, for any monitoring technique to be validated as a useful tool, biases must be identified and understood to verify the assumption that research activities do not influence subject behavior.

Nest success  $s$  (i.e., nest success is  $\geq 1$  egg hatched,) is typically used when evaluating the impact of monitoring techniques. In nest camera studies, the assumption is the presence of cameras near nests do not influence the fate of the nest, and nest success

of camera monitored and non-camera monitored nests are similar. Richardson et al. (2009) performed a meta-analysis of camera effects on daily nest survival rates and found the majority of studies reported equal or higher nest success at camera monitored nests than nests without cameras. Several potential reasons exist for this apparent increase in nest success. Often because of limited number of camera systems or to ensure abandonment does not occur (Thompson et al. 1999, Pietz et al. 2012), cameras are installed later in incubation. However, nests that are monitored in later stages of incubation have a higher probability of survival because there are fewer days remaining, resulting in a reduced the probability of observing a nest failure (Mayfield 1975). It has also been proposed that scent and the novel objects left by researchers act as a deterrent rather than an attractant toward some common predators (Richardson et al. 2009).

Few researchers report behavioral responses to cameras. Reidy and Thompson (2012) removed cameras from songbird nests in Texas when non-normal (authors did not disclose what constituted normal activity) nesting activity persisted beyond one to two hours after installation. Although removal of camera equipment may have increased nest success, no formal analysis on the effect of removal was performed, nor was there rationale provided for the selected “acclimation time” of one to two hours. In a study of nest predator identification for New Zealand Robins (*Petroica australis*) and Tomtits (*Petroica macrocephala*), Brown et al. (1998) reported a female robin standing between the camera and nest staring in the direction of the camera for approximately 16 minutes around dusk. This nest was depredated eight days later (Brown et al. 1998). The fate of this nest cannot be formally linked to this odd behavior and the small sample size prevents any meaningful analysis of the effect of the behavior on nest success (only one

bird exhibited behavior). However, these examples beg the question of how parental responses at the nest might translate to changes in reproductive success as a result of cameras deployed at bird nests.

Although many studies report no negative effect of camera presence on success, it is unknown if behaviors associated with camera installation influence nest survival. If these behaviors are indeed important to nest success, then we can use their occurrence as indicators to help determine if camera presence is likely going to result in a failed nest because of research activity. The time researchers have to make the decision to remove a camera is unknown, arbitrary, and has not been investigated. Researchers make the assumption that this logistically convenient time is also biologically significant for the nesting bird. Failure to make the decision to remove a camera within the appropriate amount of time may result in incorrect assumptions about the influence of research activity.

In this study, we examine nesting behaviors of Sharp-tailed Grouse (*Tympanuchus phasianellus*; hereafter “sharptail” or “sharptails”) in relation to video camera installation and other common nest monitoring activities. Sharptails are an upland nesting gamebird found throughout the grasslands of North America (Connelly et al. 1998). In western North Dakota, sharptail populations have been subjected to heavy human disturbances because of the natural gas and oil development and exploration. This study was conducted as an extension of Burr (2014), whose research evaluated the influence of gas and oil production relative to sharptail nest success and predator community. As part of that research, nest success was evaluated relative to the presence or absence of a camera to determine potential biases of the monitoring technique. He

found that camera monitored nests had higher daily survival rates (DSR) than those monitored using only radio telemetry to conduct regular nest checks (Burr 2014).

Although the presence of cameras was not found to be detrimental to DSR, we wanted to explore if parental behaviors influenced DSR within the first 24 hours after camera installation. Several use 24 hours as their duration between nest checks, therefore; the nest would be checked at the end of 24-hours using this method (Staller et al. 2005, Ellis-Felege et al. 2012). We hypothesized that DSR is lower when hens do not resume incubation immediately upon return to the nest (potentially increasing activity and scent at the nest), spend less time on the nest, take more recesses, and have a camera interaction (i.e., visually or physically inspect camera) within the first 24 hours after installation. We also evaluated how incubation constancy changes in relation to various research activities (*Researcher Interactions and Incubation Constancy*). Here we hypothesized that incubation constancy decreases as duration of researcher interaction increases, and is different from days with no interaction.

## **Methods**

### *Study Area*

As part of a larger study on sharptail nesting ecology, we monitored nests at two study sites in Mountrail County, North Dakota between March and August of 2012 and 2013. Belden (centroid location: N: 48.087094 W: -102.408549; area: 147.2 km<sup>2</sup>) and Blaisdell (centroid location: N: 48.269953 W: -102.086157; area: 158.3 km<sup>2</sup>) are primarily composed of rolling hills, buttes, draws, and small wetlands. Sites are dominated by agriculture that includes row crops and pasture land with scattered clusters of shrubs and a few deciduous trees. Intensity of energy development is the primary

difference between sites, with Belden being an area of “high” intensity (maximum well density of 0.95 wells/km<sup>2</sup>) and Blaisdell “low” intensity (maximum well density of 0.01 well/km<sup>2</sup>) (Burr 2014).

### *Field Methods*

We captured hens at leks (breeding grounds) using walk-in style traps (Toepfer et al. 1987) from March to mid-May. Upon capture, hens were aged, weighed, and blood was collected. We fitted hens with necklace style radio collars (either 10.7 or 16 g) along with a North Dakota Game and Fish metal leg band containing a unique identification number.

Radio-collared hens were located using hand-held, truck, and aerial-mounted telemetry every four to five days throughout the breeding season. Once hens were located at the nest we recorded number of eggs, nest attempt, Geographic Positioning Systems location (Geographic Coordinate System: North America 1983; Datum: North American Datum 1983; Projection: UTM Zone 14), and relative location (to surrounding landmarks; used as an alternative to placing visual cues near the nest like flagging).

We selected camera monitored nests based on availability of nests and proximity to other camera monitored nests in an attempt to prevent clustering. Miniature surveillance cameras containing light emitting diodes (LEDs; 950nm) and 4.3 mm lenses were used to record both day and night footage (Jet Security USA, Buena Park, CA). During 2013, the number of LEDs was increased from 7 to 24 to provide greater illumination and clarity for nighttime footage to aid in predator identification. Cameras fitted with sunshields were attached to a 0.6 m piece of steel rebar and placed approximately 0.5 m from the nest. Distance and position of the camera was dependent

on vegetation density and structure around the nest. Minimal amounts of vegetation were removed to provide a clear field of view throughout incubation. The camera box, a waterproof box (Seahorse, Corina, CA) housing a digital video recorder (DVR; Advanced Security, Belleville, IL), was connect by a cable and located at least 25 m from the camera. The DVR recorded continuously at 10 frames per second at high resolution onto a 32 gigabyte secure digital (SD) card (Kingston Technology, Fountain Valley, CA). A 12-volt 35-amp battery placed next to the camera box powered the system. Sunshield, rebar, cable, camera box, and battery were camouflaged using paint and surrounding vegetation. Camera installation took 15 – 20 minutes to complete and researchers wore latex gloves to minimize scent left in the nesting area.

We visited the camera box every three to five days to change the SD card and battery and check for nest fate. Hen presence at the nest was checked using a Tote Vision (Seattle, WA), and with telemetry (relative location to the nest). If the hen was not present, we approached the nest to check for signs indicating a successful or failed nest. If the hen appeared to be still incubating, we checked camera positioning and cleared any vegetative growth obstructing the camera view. If the nest was terminated, we used sign at the nest to determine fate and removed the camera. Attempts were made not to flush hens from nests while we performed general camera maintenance (e.g., not approaching the nest, or being quick and quiet when working near the nest). Camera maintenance typically lasted less than 5 minutes. We considered a nest successful if  $\geq 1$  egg hatched. Video was later reviewed to confirm nest fate and characterize nest behaviors.

### *Video Analysis*

Data collection began at the start time of the first video or once installation was finished (no researcher in field of view). Video was viewed using Windows Media Player (Microsoft, Seattle, WA) or by project scientists through the Wildlife@Home website (Desell et al. 2012).

### *DSR and Camera Installation*

We characterized five nesting behaviors: recess number, incubation constancy, next to nest, partial on nest, and camera interactions (Table 10). Both recess number and incubation constancy are derived from the nest recess behavior. *Nest recess* was defined as any time the hen was not incubating the eggs (i.e., sitting on the nest), and was not caused by a researcher disturbance or predator. *Recess number* is the number of recesses taken during the first 24 hours after installation. Since increased activity by parents has been shown to decrease nest success (Bukacińska et al. 1996), recess number provides an indicator for how active or restless a hen is. It also represents the tradeoff between the hen's self-maintenance (e.g., foraging) and the needs of the developing clutch (Skutch 1962). *Incubation constancy* is a concept introduced by Skutch (1962), and is the percent of either a 24-hour day (possible using continuous video as we did in this study) or during daylight hours spent incubating. This commonly used metric represents a measure of the amount of heat applied to the eggs (Skutch 1962).

We also examined how birds return to the nest by noting the presence of the *partial on nest* and *next to nest* behaviors (collectively “mode of return”). When returning to the nest after being disturbed because of a human or other animal (non-predator) hens may exhibit the partial on nest behavior. In this circumstance, hens



initiate incubation of only a portion of the total clutch (eggs are still observed in the frame rather than completely covered by the incubating hens). During the next to nest behavior, hens approach and sit directly adjacent to the nest bowl (no eggs are covered by the hen) acting as if they were incubating eggs.

Finally, we recorded the presence of any *camera interaction*. These included non-aggressive visual observation (hen's attention clearly on the camera) or a physical inspection (hen pecks the camera a few times; not overly aggressive), to an attack of the camera (hen is aggressively defending her nest against the camera).

#### *Researcher Interactions and Incubation Constancy*

Three types of researcher interactions with grouse nests occurred during our study, classified as camera installation, flushing event, and no interaction (Table 11). Camera installation was only experienced once per nest and is specific to nest camera monitoring. We categorized a flush day as a researcher activity when field technicians flushed hens to determine active incubation or to resolve camera problems. Flush days would be common disturbances experienced when performing regular nest checks without the use of cameras or radio telemetry. No interaction was categorized as days when hens were not disturbed or monitored by any physical presence of researchers.

For this analysis, we used a subset of nests that were included in the DSR and camera installation analysis, flushed by a researcher at least once, and the entire period of camera monitoring was viewed. During video review, duration and number of recess events for all days monitored up until the fate date (day the nest was hatched, abandoned, or destroyed) were recorded. For interactions with multiple days (i.e. flushed multiple

days or multiple no interaction days) average incubation constancy was calculated to provide one value for the interaction (Slay et al. 2012).

### *Data Analysis*

#### *DSR and Camera Installation*

Because of the binomial nature of nest success, it is commonly thought of in terms of probabilities. There are several ways of calculating nest success. The most basic is to calculate apparent nest success, or the proportion of successful nests. For example, of 100 nests monitored, 30 were successful, resulting in an apparent nests success probability of 30%. This method does not take into account variation in nest discovery timing and exposure days (number of days monitored), resulting in overestimation of nest success (Mayfield 1961, Mayfield 1975). Using the Mayfield method of estimation produces DSR estimates that can be applied to a nesting stage (Mayfield 1975). Though useful, this method also has its limitations. Results from this analysis are survival rates for various groups (or treatments) that can be analyzed using chi-squared statistics, resulting in a reduced sample size for each group (Dinsmore et al. 2002). There are also several assumptions made by the Mayfield method that are difficult to validate because of logistical restraints (i.e., known fate date, nest age, and constant survival throughout stage). The nest survival model in program MARK (White and Burnham 1999) calculates DSR estimates, but has the added flexibility of investigating the influence of covariates using an information theoretic approach. For these reasons, we chose to utilize this program for analysis.

We constructed models that represented our biological hypotheses with behavioral covariates of interest and DSR (Table 11) (Burnham and Anderson 2002)

using Program MARK (White and Burnham 1999). Because of prior knowledge of DSR differences between our two study sites (Burr 2014), site was included in all models as a covariate. Relative importance of each model was evaluated using Akaike's Information Criterion corrected for small sample size ( $AIC_c$ ) (Burnham and Anderson 2002). Likelihood and relative model strength was compared using  $AIC_c$  weights ( $w_i$ ) to determine the simplest hypothesis that explained DSR best (Burnham and Anderson 2002). We evaluated the magnitude of effect of covariates using model-averaged estimates, and calculated odds ratios (OR) for interpretation. Odds ratio confidence intervals that exclude 1.0 are considered to be statistically significant, while odds ratios themselves are used to determine how many times more or less likely an event is to occur compared to a baseline category.

#### *Researcher Interactions and Incubation Constancy*

Since repeated observations at a nest occurred, we used a mixed model approach (PROC MIXED) in SAS (SAS Institute 2003) to account for the dependency of multiple observations on the nest (Anderson et al. 2008). Covariates included site and year, as they contribute to variability in other aspects of sharptails reproductive ecology (Burr 2014), in addition to type of disturbance (flush, installation, and no interaction). Nest ID was categorized as our random effect.

### **Results**

A total of 103 nests were monitored using cameras during the two-year study (47 nests 2012; 56 nests 2013). Of those, 29 (28.16) failed because of nest predation, 13 (12.62%) because of abandonment, four (3.88%) because of hen mortality, and five (4.854%) from agricultural practices (four nests destroyed by cattle, and one destroyed by

haymaking equipment). Of the 13 abandoned nests, 10 were abandoned within 48 hours after camera installation. Of the 103 nests monitored, 53 were successful.

### *DSR and Camera Installation*

We evaluated 70 nests of incubating females to determine role of behaviors after installation on DSR. Apparent nest success was 51.4% for all nests. We omitted nests still in the egg-laying stage (2 nests), those where the entire 24-hour period was not captured because of camera malfunctions (11) or when hens tilted the camera off view of the nest during a camera interaction (2), and any nests abandoned, hatched or depredated within the first 24 hours (9 nests abandoned; 2 hatched; 4 depredated).

Within the first 24 hours after installation hens took an average of 2.44 recesses and exhibited an incubation constancy of 89.9% (Table 12). Hens associated with failed nests in 2012 at Belden took more recesses than their counterparts (Table 12). In addition, hens associated with successful nests in 2013 at Belden exhibited greater incubation constancy (Table 12). At 50.0% of the nests, we observed the presence of a partial on nest behavior during the first 24 hours of camera monitoring (Table 12). We found 31.4% of hens exhibited the next to nest behavior (Table 12). Only 15.7% ( $n = 11$ ) of hens had an interaction with the camera within the first 24 hours after installation.

We constructed 17 models using behaviors exhibited within the first 24 hours after installation (Table 13). Within our top models (10 models contained 95% of model weights), the presence of the “partial on nest” and “next to nest” behaviors were the most common parameters (Table 13). Nests of hens that sat partially on their nest were 3.08 times *more likely* to succeed than those that did not (Table 14). In contrast, nests of hens that sat next to their nest were 3.08 times *less likely* to succeed (Table 14). The next to

nest behavior was only observed after a human had flushed a hen off the nest, while the partial on nest behavior was also observed after predators flushed hens. Incubation constancy was not strongly correlated with DSR (Table 14). Number of recesses and presence of a camera interaction within the first 24 hours showed little to no correlation with DSR (Tables 14).

#### *Researcher Interactions and Incubation Constancy*

Based on 16 nests, hens of successful nests had higher incubation constancies for all three disturbance types (Table 15). The same incubation constancy pattern was observed for nests in 2012 (Table 15). Blaisdell hens had marginally higher incubation constancies during flush ( $\Delta = 0.1\%$ ) and no interaction days ( $\Delta = 0.12\%$ ) than Belden hens; however, hens at Belden incubated 4.0 % longer than Blaisdell hens during installation days (Table 15). Incubation constancy decreased by 6.7% during installation day ( $P = 0.002$ ), and 3.1% during a flush day ( $P = 0.129$ ) compared to a no interaction day (Table 16).

### **Discussion**

The mode of return most accurately predicted DSR. Expression of the partial on nest behavior, a response observed when returning after a predator or non-predator animal flushes the hen off the nest, increased DSR. Next to nest, a response unique to researcher interactions with the nesting hen, was equal in magnitude but decreased DSR. These behaviors are likely a form of anti-predatory response influenced by the type of disturbance experienced. It is well established that humans induce responses that predators do not. Incubating Hooded Plovers (*Thinornis rubricollis*) have been observed to leave nests unattended longer when disturbed by a human than by a non-human

(Weston and Elgar 2007). Brunton (1990) found that Killdeer (*Charadrius vociferous*) displayed more intense parental defense behaviors more frequently in response to humans than to natural predators. They suspected differences were the result of the close proximity humans came to the nest and chicks, something predators successfully deterred by distraction displays did not do (humans came within 1 m; closest predator came within 21 m) (Brunton 1990). Similarly, our research suggests that differences between human and predator behavior near nests result in different responses from incubating parents.

We observed a negative relationship between incubation constancy and level of research interactions. This can have implications for cameras installed at nests during inclement weather or early in incubation. Afton (1980) found that long absences during cold and wet weather can slow embryonic development. Habituation to other anthropogenic disturbances may explain why hens at Belden (an area subjected to heavy gas and oil development) were less affected by greater research disturbance than Blaisdell hens (an area of minimal gas and oil development; see Burr 2014). The differences between years could be correlated with weather (2012 being one of the earliest breeding seasons on record, 2013 one of the latest). During 2013, hens may not have been able to build up enough energy stores because of persistent snow cover. Low energy stores at the onset of incubation have been shown to decrease incubation constancy in Greater Sage-Grouse (*Centrocercus urophasianus*) (Coates and Delehanty 2008), and several species of waterfowl (Aldrich and Raveling 1983, Thompson and Raveling 1987, Yerkes 1998). Despite incubation constancy on installation day being statistically different than a no interaction day, this trend was likely not biologically significant given incubation constancy on installation day was not a good predictor of DSR. Similar relationships

between nest attendance and nest survival have been observed in other species. Varboven et al. (2001) found that although nest attendance of Eurasian Oystercatchers (*Haematopus ostralegus*) decreased when researchers were in the area. There was no noticeable change in egg predation rates.

Because of a limited sample size, we did not examine the relationship between frequency of research-related flushes and incubation constancy and DRS in sharptails. Frequent disturbances at colonies of nesting birds have resulted in avoidance by re-nesters later in the breeding season (Tremblay and Ellison 1979, Safina and Burger 1983). This could have consequences for sharptails. Along with their propensity for nesting close to leks (Connelly et al. 1998) and the threat of declining habitat availability (NRCS 2007), frequent disturbance may force hens to forgo subsequent nesting attempts; a tradeoff that may result in reduced lifetime reproductive output.

When timing camera installation, we recommend installing fast, a few days into incubation, and during fair weather. Duration of camera installation similar to the duration of a recess may reduce any “excess” time incubating parents have to spend away from the nest (Brown et al. 1998). To even further reduce disturbance, we recommend waiting to install cameras when the incubating parent is on a recess (i.e., takes recess on own accord) if logistically feasible. Pietz and Grandfors (2000) also suggest installing cameras near evening, forcing incubating parents to return to the nest before nightfall and reducing the amount of time spent off the nest. Although eggs are more viable at low ambient temperatures during pre-incubation (Arnold 1993), nest abandonment decreases with increased nest stage (Pietz and Grandfors 2000). Because of this, we encourage verifying initiation of incubation via egg candling, floating, or monitoring parent activity

around the nest using radio telemetry prior to installing cameras. We believe that the 10 nest abandonments within 48 hours of installation in our study were most likely caused by research activity. Nine of those were located at Blaisdell, and 7 were during 2013. A combination between decreased nest attendance and increased nest predation at Blaisdell (compared to Belden; Chapter 2), and the difference between field crews could possibly account for these abandonments.

Camera placement and concealment should be considered. Using paint and surrounding vegetation for camouflage can reduce the chance of being noticed by both predators and the incubating parent. If a clear entrance or exit exists, placing the camera to the sides would decrease the chances of the camera being directly in the birds view. Ensuring a clear view of the nest by removing and adjusting minimal amounts of vegetation during installation will reduce the number of re-visits throughout incubation. Prevent alteration of interactions between predators and nests (both an increase and decrease in predation) by reducing scent left by wearing rubber boots or gloves while handling, installing, and adjusting cameras. Finally, minimize trampling down of vegetation with repeated trail use or excessive movement during installation.

This research is one of the few to evaluate potential impacts of camera monitoring methods on bird behavior. It is difficult to observe nesting behaviors without the presence of a camera or a human, and both induce their own potential biases. In fact, Mayfield (1975) suggests that any nest observed is no longer in a natural state, making it difficult for us to define behaviors as “natural” or “unnatural.” We did, however, examine the range of behaviors and their stimuli, giving us the ability to make inferences



about how various levels of human and non-human disturbances may influence nesting behaviors.

The purpose of examining behaviors within the first 24 hours after installation was to determine if there is a way of quickly identifying behaviors detrimental to nest success. As technology advances and popularity of wireless recording and viewing capabilities increases, our ability to identify and respond to these behaviors will be possible. Responses may vary by taxa, reproductive strategy, and habitat; however, little is reported and therefore unknown about variability in behaviors and their effects. By using this approach, we were able to broaden the understanding of how researcher activities influence nest success. These insights provide future nest camera monitoring efforts to identify and remove nests from analyses that violate the assumption that research activity does not influence behaviors or outcomes, providing a dataset that more accurately depicts a “natural” system. Such validation of monitoring methods for both effectiveness and potential impacts is encouraged as new and expanded technologies continue to be used in the field of wildlife ecology.

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## Tables

Table 10. Classification and definition of parameters used for nest success analysis in program MARK. Abbreviations in parentheses used in figures and tables.

Parameter	Definition
Number of Recesses <sup>a</sup> (rss_num)	Number of recesses during the first 24 hours after camera installation.
Incubation Constancy <sup>a</sup> (incu_con)	Time spent on nest during first 24 hours after return to incubation.
Camera Interaction <sup>b</sup> (ci)	Presence of a camera interaction.
Next to Nest <sup>b</sup> (nxn)	Presence of hen lying next to nest.
Partial on Nest <sup>b</sup> (pnn)	Time spent laying partially on nest; not all eggs are being covered by hen.

<sup>a</sup>Data type: continuous

<sup>b</sup>Data type: binary

Table 11. Classification and definition of parameters for repeated measures analysis of incubation constancy using PROC MIXED procedures in SAS. All parameters are binary variables.

Parameter	Definition
site	Study sites: Belden* or Blaisdell.
year	Years monitored: 2012* or 2013.
installation day	Incubation constancy on the day of camera installation.
flush day	Incubation constancy on days when hen was flushed because of research activity <i>not</i> including installation day.
no interaction day	Incubation constancy on days when no researcher activity occurred in the nesting area.

\*Baseline for comparison.



Table 12. Summary statistics of behaviors exhibited during the first 24 hours after camera installation. Organized by nest fate (successful and failed), site (Belden and Blaisdell), year (2012 and 2013), and over all nests.

	Successful	Failed	Belden	Blaisdell	2012	2013	All
<i>Number of Recesses</i>							
Mean	2.25	2.65	2.63	2.29	2.52	2.39	2.44
SD	1.48	1.81	1.88	1.43	1.77	1.57	1.65
Min	0.00	1.00	1.00	0.00	0.00	0.00	0.00
Max	6.00	9.00	9.00	6.00	9.00	6.00	9.00
<i>Incubation Constancy (percent of 24-hr day)</i>							
Mean	91.39	88.27	90.84	89.09	93.37	87.18	89.92
SD	7.79	10.52	6.82	11.00	2.81	11.47	9.25
Min	59.87	49.53	72.15	49.53	87.10	49.53	49.53
Max	97.78	90.10	97.78	99.10	99.10	97.78	99.10
<i>Next to Nest (number of nests)</i>							
Number	9.00	13.00	13.00	9.00	9.00	13.00	22.00
<i>Partially on Nest (number of nests)</i>							
Number	22.00	13.00	17.00	18.00	13.00	22.00	35.00
<i>Camera Interaction (number of nests)</i>							
Number	9.00	2.00	8.00	3.00	7.00	4.00	11.00

Table 13. Daily survival rate (DSR) models relative to behaviors exhibited within the first 24 hours after camera installation ranked by lowest AIC<sub>c</sub> score from 70 nests of incubating females. Covariate abbreviations explained in Table 1.

Model	AIC <sub>c</sub>	Δ AIC <sub>c</sub>	w <sub>i</sub>	L	K	Deviance
site + pnn + nxn	303.89	0.00	0.71	1.00	4	295.86
global	308.70	4.81	0.06	0.09	7	294.61
site + pnn	309.30	5.41	0.05	0.07	3	303.28
site + incu_con + pnn	309.51	5.63	0.04	0.06	4	301.48
site + nxn	310.66	6.77	0.02	0.03	3	304.64
site + pnn + ci	310.97	7.08	0.02	0.03	4	302.94
site	311.29	7.40	0.02	0.03	2	307.28
site + incu_con + nxn	311.67	7.78	0.01	0.02	4	303.63
site + incu_con	311.95	8.06	0.01	0.02	3	305.93
intercept only	312.37	8.48	0.01	0.01	1	310.36
site + nxn + ci	312.42	8.53	0.01	0.01	4	304.39
site + rss_num	312.78	8.89	0.01	0.01	3	306.76
site + ci	313.07	9.18	0.01	0.01	3	307.05
site + incu_con + ci	313.63	9.75	< 0.01	0.01	4	305.60
site + incu_con + rss_num	313.65	9.76	< 0.01	0.01	4	305.61
site + rss_num + ci	314.71	10.83	< 0.01	< 0.01	4	306.68
site + incu_con + rss_num + ci	315.48	11.59	< 0.01	< 0.01	5	305.42

Table 14. Model averaged beta ( $\beta$ ) estimates and odds ratios for parameters used in daily nest survival analysis of behaviors within the first 24 hours after camera. Bolded parameters are those shown to be statistically significant ( $\beta$  L CI and U CI do not include 0; OR L CI and U CI do not include 1). Abbreviations explained in Table 1.

	$\beta$	$\beta$	$\beta$	$\beta$	Odds Ratio	OR	OR
Covariate	Estimate	SE	L CI	U CI	(OR)	L CI	U CI
intercept	3.68	0.69	2.33	2.03	39.58	10.30	152.20
site	-0.81	0.39	-1.57	-0.05	0.44	0.21	0.95
incu_con	0.02	0.02	-0.02	0.05	1.02	0.98	1.06
rss_num	-0.08	0.11	-0.30	0.14	0.93	0.75	1.15
<b>pnn</b>	<b>1.13</b>	<b>0.43</b>	<b>0.28</b>	<b>1.97</b>	<b>3.08</b>	<b>1.32</b>	<b>7.17</b>
<b>nxn</b>	<b>-1.13</b>	<b>0.46</b>	<b>-2.02</b>	<b>-0.23</b>	<b>0.32*</b>	<b>0.13</b>	<b>0.79</b>
ci	-0.18	0.48	-1.12	0.76	0.83	0.33	2.14

\*For interpretation:  $1/\text{OR} = 3.09$  times *less* likely to occur.

Table 15. Summary statistics for average incubation constancy (percent of 24-hr day) by interaction day type (i.e. installation day, flush day, and no interaction day). Organized by nest fate (successful = 9 nests and failed = 7 nests), site (Belden = 9 nests and Blaisdell = 7 nests), year (2012 = 9 nests and 2013 = 7 nests), and over all nests. If there were multiple flush days and no interaction days for one nest, average incubation constancy was calculated.

		Installation Day				Flush Day				No Interaction Day			
		Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
<i>All Nests</i>		88.54	9.63	59.501	96.96	92.12	2.69	87.34	96.69	95.23	1.94	90.40	97.56
<i>Fate</i>	Successful	88.76	11.38	59.51	96.96	92.46	2.53	88.47	95.96	95.54	1.31	93.08	97.00
	Fail	88.26	7.69	74.50	96.23	91.69	3.03	87.34	96.69	94.82	2.66	90.40	97.56
<i>Site</i>	Belden	90.27	7.17	74.50	96.23	92.07	3.21	87.34	96.69	94.98	2.54	90.40	97.56
	Blaisdell	86.31	12.36	59.51	96.96	92.19	2.09	89.73	95.96	95.54	0.75	94.43	96.56
<i>Year</i>	2012	93.09	3.03	87.10	96.96	92.15	2.67	88.47	96.69	95.77	1.28	93.08	97.56
	2013	82.69	12.20	59.51	93.65	92.08	2.93	87.34	95.96	94.53	2.49	90.40	97.00

Table 16. Influence of interaction type on incubation constancy derived from repeated measures analysis using PROC MIXED procedure in SAS with baseline for site was Belden, year was 2012, and no interaction for installation and flush day.

Parameter	$\beta$	SE	df	<i>t</i>	<i>P</i>
intercept	82.58	2.77	13	29.84	<0.01
site	1.16	1.64	30	0.71	0.49
year	3.92	1.64	30	2.39	0.02
inst_day	6.69	1.99	30	3.36	<0.01
f_day	3.11	1.99	30	1.56	0.13

## CHAPTER IV

### CONCLUSIONS

The Upper Midwest is experiencing dramatic landscape changes through grassland conversion and energy extraction. Sharp-tailed Grouse (*Tympanuchus phasianellus*) (hereafter “sharptail” or “sharptails”) inhabit these same areas that are undergoing these changes. As an indicator species of grassland health (Vodehnal and Haulfer 2007, Dyke et al. 2011) the need to study the influence of the landscape and energy development on sharptails is ever-growing. Developments in camera technology provide the ability to observe the once unknown nest activities of many avian species. Although valuable, it is necessary to recognize the potential influence nest camera monitoring has on hen behavior (Brown et al. 1998) which may lead to changes in nest success (Richardson et al. 2009). The goal of this research was to evaluate the influence of human activity (via land-use and research activities) on sharptail nest attendance patterns.

We installed miniature infrared surveillance cameras at 103 sharptail nests during the summers of 2012 and 2013. Of those a subset of 55 nests were reviewed for nest attendance patterns from camera installation to nest fate. We used a repeated measures analysis to determine how nest attendance patterns are influenced by characteristics of the landscape, hen, and nest (Chapter 2). To evaluate our method of nest camera monitoring we reviewed the first 24 hours after camera installation for 70 nests (Chapter 3). We modeled daily nest survival rates to determine how behaviors following camera

installation influence nest survival. In addition, we used a repeated measures analysis to determine if incubation constancy (the proportion of time eggs receive direct heat from incubating parents during 24 hours) differed between days with various research activities (i.e. camera installation, nest checks, and no research activity).

We found that hens incubate for approximately 95.2% of the day and took approximately 2.5 recesses for 27.6 minutes each. Year was the most dominant driver of nest attendance patterns. We suspect that the primary difference between years was related to winter and spring weather resulting in more energy devoted to thermoregulation and a shorter breeding season. We observed what appeared to be decreased parental investment at Blaisdell compared to Belden and suspect that a larger predator population (resulting from less human development) and higher nest predation to be drivers of this pattern (McNew et al. 2011). We did not find any landscape covariates to predict nest attendance patterns in any direction; however, we did observe differences in percent developed land between the two sites, which translates into Belden having a greater proportion of the landscape devoted to roads. Although none of the covariates we used predicted nest success, there could be others that more heavily influence these patterns.

We have yet to understand the influence of land use changes and energy development on other aspects of sharptail ecology. Out of 55 nests, we only observed 2 to be within 250 m of a well. Both nests occurred at Belden during 2013, when the site experienced an approximate 24% increase in oil well density. As scientists we need to begin to pinpoint specific characteristics about the landscape or anthropogenic features that help or hinder optimization of nest attendance patterns (e.g., distance to and density

of flaring wells, number of wells per pad, number of active drilling rigs in the area, types of roads and intensity of traffic, etc.). In addition, we still do not know how land use changes and energy development influence brood success, adult survival and lek attendance. Regions with natural gas and oil reserves will be faced with greater pressure to produce with increasing demand for oil, and areas with fertile soil are similarly pressured to produce crops for food and biofuels (Searchinger et al. 2008, Wright and Wimberly 2013). It is the responsibility of scientists representing our natural resources (including flora, fauna, and natural energy reserves) to collaborate, continually monitor and find ways to reduce the impact of oil and natural gas extraction on wildlife.

We observed hens to take 2 to 3 recesses within the first 24 hours after camera installation and incubated for approximately 89.9% of the day. Apparent nest success was 51.4% for the 70 nests we used to analyze the influence of behaviors related to camera installation to daily nest survival rates. We found that the way hens approach the nest to be the best predictors of nest success. Nests with hens that sat partially on the nest (a behavior also displayed when hens are flushed off nest due to other animals) were 3.08 times more successful than those that did not. Conversely nests of hens that sat next to the nest (a behavior observed only when humans were the cause of hens being flushed off nests) were 3.09 times less likely to succeed. We suspect that these two behaviors are stress responses, and they differ due to the way researchers and other animals behave at the nest (i.e. humans spend more time at the nest than animals that do not depredate nests). In addition, we found that incubation constancy was significantly lower on camera installation days compared to days when researchers did not visit the nest. There was no difference in incubation constancy between days when researchers visited the nest



to perform a nest check or quickly adjust the camera or surrounding vegetation. These results are expected because the time it takes to install a camera is longer (by approximately 15 minutes) than a nest check or adjustment of the camera or surrounding vegetation.

The major caveat to this study is that we are unable to know for certain how behaviors associated with camera use influence nest survival because we cannot monitor nests without the presence of a camera or researcher (each impose their own biases). To account for this we looked at the range of hen responses to camera monitoring. Mayfield (1975) suggests that it is impossible for researchers to truly observe natural behaviors because the subject has been exposed to the presence of the researcher. Although we cannot avoid this paradox, there are several ways to reduce as much research bias as possible.

Several logistical considerations should be accounted for to ensure optimal video quality to meet study objectives while reducing the potential influence of nest cameras on nest success. Nest location, and surrounding vegetation determine how cameras are to be concealed. Concealment of cameras and associated equipment is essential because it prevents interactions between the nesting birds and the camera, as well as any interactions with nest predators. Power requirements are determined by nest ease of access to the location and recording device requirements. Cameras may need light emitting diodes (LEDs) for night vision to observe events in low-light and nighttime nesting events. Lens focal length determines how far the camera can be placed from the nest, while retaining image focus (Cox et al. 2012). Video recorder devices and settings are determined by the data required, ranging from still images, motion triggered, time

lapsed, and continuous video. Finally, strategies for secure data storage and filtering of these massive datasets should be well developed prior to data collection.

The purpose of this study was to determine how human actions influence one aspect of sharptail nesting ecology, nest attendance. To our knowledge, this is the first study to relate nest attendance of sharptails to the landscape and gas and oil development. In addition, we are one of the few to evaluate the potential impacts of camera monitoring on bird behavior and relate those behaviors to nest success. Results from this study reaffirm the need to collect unbiased data, make management decisions based on robust results, and to continually monitor wildlife using appropriate, unbiased methods to clearly determine the impact of anthropogenic changes on wildlife.

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