PARTICIPATION IN THE LIGHT GOOSE CONSERVATION ORDER AND EFFECTS ON BEHAVIOR AND DISTRIBUTION OF WATERFOWL IN THE RAINWATER BASIN OF NEBRASKA

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by

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The undersigned, appointed by the dean of the Graduate School, have examined the thesis entitled

PARTICIPATION IN THE LIGHT GOOSE CONSERVATION ORDER AND EFFECTS ON BEHAVIOR AND DISTRIBUTION OF WATERFOWL IN THE RAINWATER BASIN OF NEBRASKA

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ABSTRACT

The Light Goose Conservation Order (LGCO) was initiated in 1999 to reduce mid-continent populations of light geese (lesser snow geese [*Chen caerulescens*] and Ross's geese [*C. rossi*]). However, there was considerable concern about potential for LGCO activities to negatively impact non-target waterfowl species in the Rainwater Basin (RWB) of Nebraska; specifically hunting disturbance may limit nutrient acquisition during this important spring migration period. As a result, regulations were established with caution and currently allow hunting four days a week (Saturday, Sunday, Wednesday, and Thursday), with a total of 16 public wetlands closed to the LGCO. However, the effects of LGCO regulations on waterfowl distribution and behavior, as well as hunter participation and satisfaction are relatively unknown. To evaluate the effects of the LGCO in the RWB, we paired wetlands open and closed to hunting (hunt category) at which we quantified waterfowl density and behavior and recorded all hunter encounters during springs 2011 and 2012. We constructed hourly energy expenditure (*HEE*) models based on behavior data collected for mallards (*Anas platyrhynchos*) and Northern pintails (*A. acuta*; hereafter pintails). In spring 2012 we also conducted a mail survey to evaluate hunter opinions regarding current LGCO regulations and future management strategies for controlling light goose populations.

We encountered a total of 70 hunting parties on study wetlands, with over 90% of these encounters occurring during early season when the majority of waterfowl used the RWB region. We detected greater densities of dabbling ducks (*Anas* spp.), as well as mallards and pintails on wetlands closed to the LGCO. We detected no effects of hunt day in the analyses of dabbling duck densities. We detected no differences in mean

weekly dabbling duck densities among wetlands open to hunting, regardless of weekly or cumulative hunting encounter frequency throughout early season. Additionally, hunting category was not a predictor for the presence of greater white-fronted geese (*Anser albifrons*; hereafter white-fronted geese) in a logistical regression model.

In 2011 dabbling ducks spent more time feeding and less time resting in wetlands closed to hunting during early season, but no differences in behaviors were detected between hunt categories during late season when hunting activities subsided. In 2012, dabbling ducks spent more time feeding and less time resting in wetlands open to hunting during early season. However, dabbling ducks still spent more time foraging in wetlands open to hunting during late season when hunting encounters diminished; indicating differences in habitat between open and closed wetlands may have played a more important role in foraging behaviors during 2012. We detected no differences in behaviors of lesser snow geese or white-fronted geese between hunting categories in early season when the majority of hunting encounters were recorded. Mallards had greater *HEE* on wetlands closed to hunting, compared to wetlands open to hunting; therefore, greater energy spent by mallards cannot be attributed to hunting disturbance. We also detected no effects of hunt day on dabbling duck behavior or *HEE*.

In our mail survey, hunters strongly agreed that special regulations to minimize disturbance to other waterfowl species during the LGCO in the RWB are an important management strategy. Hunters were also generally satisfied with current regulations, however, when given alternative choices they were most supportive of a LGCO season open to hunting all day, seven days a week, but with more publicly owned wetlands closed to hunting. Hunters also strongly agreed that population control of light geese is

an important wildlife management issue; however, there was relatively neutral support for wildlife officials using alternative methods for controlling light goose populations. Surveyed hunters who participated during the 2012 LGCO were less supportive of any direct control methods presented in our survey, compared to non-participants.

Our results suggest a refuge system of wetlands closed to hunting during the LGCO in the RWB is an important management strategy in providing reduced disturbance for non-target waterfowl species at stopover sites. However, we found no effects of hunt day in analyses of dabbling duck densities, behavior, or *HEE*. Dabbling duck densities were also similar on wetlands open to hunting, regardless of observed hunting frequency. Additionally, we found no effects of hunting on behavior or distribution of white-fronted geese. We suggest providing a LGCO season with more allowable hunting time (i.e., open seven days a week), with the current network of closed wetlands remaining in place, will have minimal additional impacts to non-target waterfowl using the RWB for spring migration. Additionally, providing more hunting time may increase hunter satisfaction and participation during the LGCO season in the RWB and ultimately aid in the reduction of mid-continent light goose populations. We also suggest a more in-depth survey approach that gauges not only hunter support, but support of the general public regarding options for direct control of light geese and expanding survey distribution to states in other flyways with overabundant light goose populations. Public education and support will be essential for wildlife professionals to proceed with using any methods of direct control on light goose populations.

CHAPTER I

INTRODUCTION AND STUDY OBJECTIVES

Mid-continent populations of light geese (lesser snow geese [*Chen caerulescens*] and Ross's geese [*C. rossi*]) have increased considerably over the last thirty years (Abraham et al. 2005, U.S. Fish and Wildlife Service [USFWS] 2007). From the late 1960s to the mid-1990s, populations increased 5-7% annually and are currently estimated at greater than 6 million breeding birds (Abraham et al. 2005). Growth of mid-continent light goose populations can be attributed to increased availability of high energy waste grains and establishment of refuges along migration pathways (Alisauskas and Ankney 1992, Jefferies et al. 2004, Abraham et al. 2005, USFWS 2007). The combination of these two landscape changes has contributed to greater annual survival and lower variation in annual survival than historically observed in light goose populations (Jefferies et al. 2004, Abraham et al. 2005, USFWS 2007).

Greater annual survival and subsequent overpopulation of light geese have resulted in long term damage to some arctic breeding areas (Abraham and Jefferies 1997). Intense grazing of shoots, grubbing of roots and rhizomes by light geese, along with a short growing season, have led to irreversible vegetation loss, increased soil salinity, erosion, and desertification in some areas (Srivastava and Jefferies 1996, Abraham and Jefferies 1997, Jefferies and Rockwell 2002). Habitat destruction in artic nesting areas has also negatively impacted other avian species breeding in these areas by reducing foraging opportunities and eliminating nesting cover (USFWS 2007).

Prior to 1999, waterfowl managers attempted to reduce light goose populations through implementation of increasingly liberal hunting regulations within current Federal frameworks, including larger bag limits and longer season lengths (USFWS 2007). However, gradual changes in regular season frameworks proved to be relatively ineffective at controlling light goose populations (USFWS 2007). In an effort to increase light goose harvest in the Central and Mississippi Flyways, the USFWS implemented the Light Goose Conservation Order (LGCO) in 1999, which allowed the legal harvest of light geese after March 10th, following closure of all other waterfowl seasons. Until the LGCO was enacted, no legal waterfowl hunting had taken place after March 10th since the signing of the Migratory Bird Treaty Act in 1918 (USFWS 2007). The LGCO also authorized use of electronic calls and unplugged shotguns, removed bag limits, and extended shooting hours for light geese (USFWS 2007). The overall management goal of the LGCO was to reduce mid-continent light goose populations by 50% from the level observed in the late 1990s (USFWS 2007). Since the LGCO began, numbers of wintering light geese have decreased in some years, but have generally remained stable (USFWS 2007). As of 2006, the number of wintering light geese remained 109% higher than the threshold population level established by the Central and Mississippi Flyway Councils (USFWS 2007).

Throughout the period of high population growth, light geese have shown considerable flexibility in habitat use on wintering, breeding, and migration areas (Abraham et al. 2005). One such change in habitat use has been the westerly movement of light geese into the Rainwater Basin of Nebraska (RWB) from their more traditional spring migration route along the Missouri River (Gersib et al. 1989, Krapu et al. 2005,

Vrtiska and Sullivan 2009). Waterfowl surveys in the RWB conducted during spring of 1980 indicated light geese accounted for < 2% of geese on surveyed wetlands and surrounding agricultural lands (Krapu et al. 2005). However, by 1990 the RWB had become a major staging area for mid-continent light geese (Krapu et al. 2005, Vrtiska and Sullivan 2009) and Vrtiska and Sullivan (2009) estimated approximately 7.3 million light geese in the RWB and adjacent Central Platte River Valley during peak spring migration in 2001.

Given the high energetic costs of migration and subsequent breeding activities, spring migration is a period of extreme nutritional demand in the annual cycle of migratory birds (Arzel et al. 2006). Thus, migratory birds are likely more affected by disturbance during spring compared to other times of the year, because of high energy demands (Madsen and Fox 1995). Spring nutrient reserves and body condition of migratory birds have been linked to subsequent survival and probability of reaching breeding grounds (Mainguy et al. 2002, Drent et al. 2003, Gunnarsson et al. 2005), as well as reproductive effort and breeding success (Ankney and MacInnes 1978, Farmer and Wiens 1999, Alisauskas 2002, Mainguy et al. 2002, Devries et al. 2008). In addition to light geese, the RWB also supports millions of other waterfowl during spring migration, providing habitat for an estimated 50% of the mid-continent mallard (*Anas platyrhynchos*) population and 30% of the continental Northern pintail (*A. acuta*) population (Gersib et al. 1989, Krapu et al. 1995, LaGrange 2005, Vrtiska and Sullivan 2009). Bishop and Vrtiska (2008) estimated approximately 9.8 million waterfowl use the RWB region each year during spring migration. Hunting during the LGCO is a potential source of disturbance for non-target waterfowl species during spring migration in the

RWB and may influence habitat use, behavior, energy expenditure, and body condition (Webb et al. 2010, Webb et al. 2011, Pearse et al. 2012). The RWB may also function as a geographic bottleneck in which large proportions of certain avian populations widely dispersed on breeding and wintering areas can be affected by factors occurring at localized stopover sites, which may include hunting disturbance (Myers 1983).

Light goose populations can become highly concentrated at stopover sites, making them potentially more susceptible to harvest by hunters and thus aiding in population reduction. However, the LGCO in the RWB was implemented with caution due to considerable concern about potential negative impacts on non-target species in an important spring migration area. Current implementation of the LGCO in the RWB attempts to maximize harvest of light geese while minimizing impacts to non-target species. For management purposes, the RWB area was divided into eastern (Zone 1) and western (Zone 2) regions, separated by U.S. Hwy 281 (Figure 1.1). Current regulations during the LGCO limit hunting in zones 1 and 2 to four days a week (Saturday, Sunday, Wednesday, and Thursday), and close 16 specific public wetlands to hunting during the LGCO. Hunting of light geese is permitted seven days a week in both zones after the third week in March, with the LGCO season ending on April 1st in zone 2 and during the second week of April in zone 1.

It has been hypothesized that since implementation of the LGCO in the RWB, participant and waterfowl behavior have changed, and that the original goal of maximizing light goose harvest is not being met. Therefore, the goal of this study was to assess how current LGCO regulations along with hunting participation affect waterfowl habitat use, behavior, and energy expenditure within the RWB. These data will be used

in conjunction with information gathered from LGCO participants through a mail survey evaluating satisfaction with current LGCO regulations to assess whether the current framework meets the original management goals and explore potential regulatory changes. Additionally, recent evidence suggests mid-continent light goose populations continue to increase despite the implementation of the LGCO (Alisauskas et al. 2011). Therefore, we also used our mail survey to assess hunter opinions and support for potential alternative methods for controlling light goose populations.

STUDY OBJECTIVES

Objective 1. Quantify duration, distribution, and frequency of participation in the Light Goose Conservation Order in the Rainwater Basin.

Objective 2. Evaluate effects of the Light Goose Conservation Order on habitat use, behavior, and energy expenditure of waterfowl during spring migration in the Rainwater Basin.

Objective 3. Determine migratory bird hunter satisfaction with current regulations and factors influencing participation during the Light Goose Conservation Order in the Rainwater Basin and evaluate hunter opinions of alternate management strategies for controlling light goose populations.

THESIS FORMAT

Chapters 2, 3, and 4 of this thesis were written as independent manuscripts with multiple authors to be submitted for publication in peer-reviewed journals. Some introductory material and figures are repeated throughout chapters and an independent literature cited section follows each chapter. As a result, plural nouns “we” and “our” rather than “I” are used throughout each chapter.

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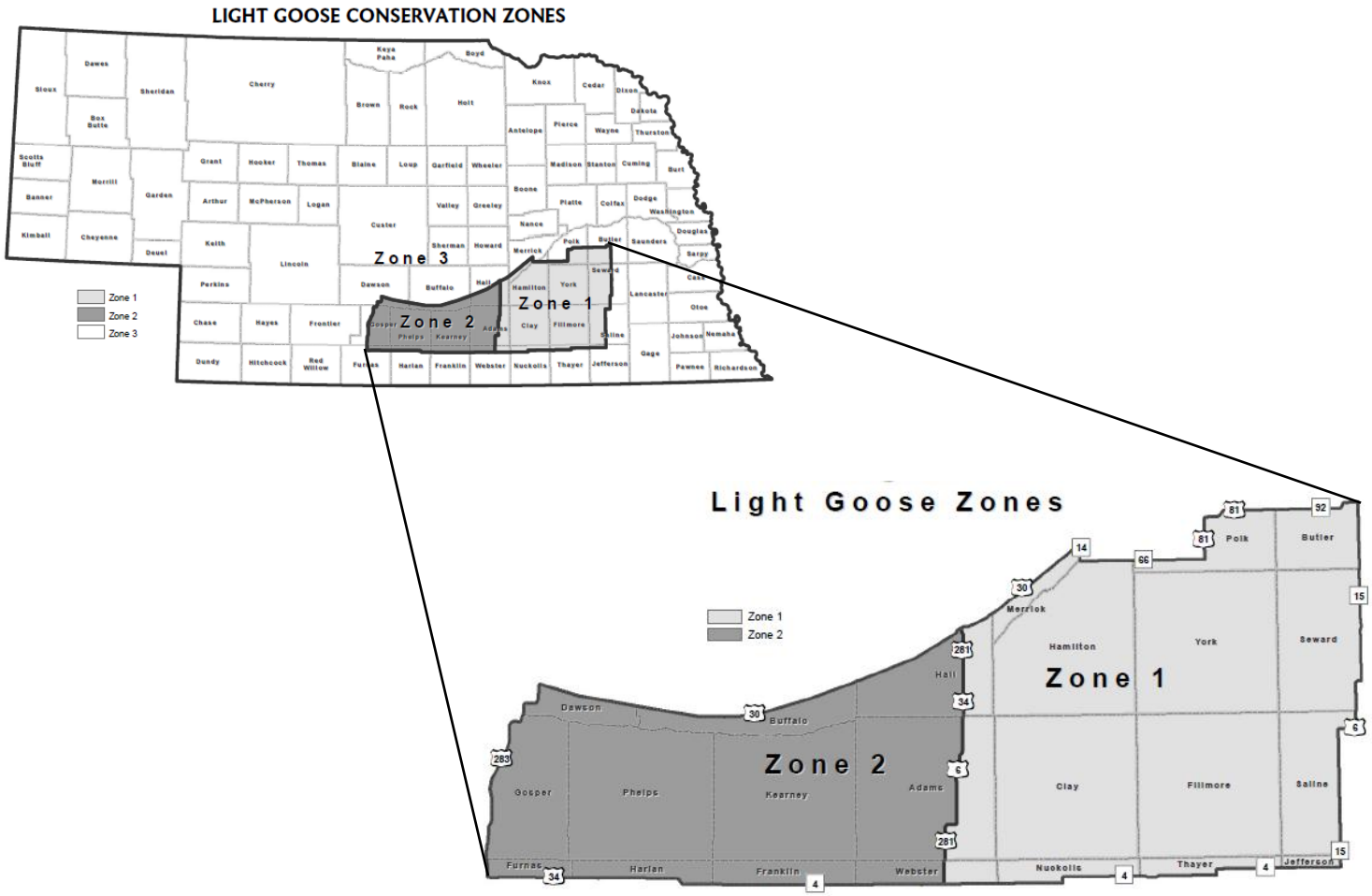

Figure 1.1. Light Goose Conservation Order zones 1 and 2 in the Rainwater Basin of south-central Nebraska where hunting during the Conservation Order was restricted to four days a week (Wednesday, Thursday, Saturday, Sunday) and 16 public wetlands were closed to the Conservation Order.

CHAPTER II

EFFECTS OF THE LIGHT GOOSE CONSERVATION ORDER ON WATERFOWL DISTRIBUTION IN THE RAINWATER BASIN OF NEBRASKA

INTRODUCTION

Hunting disturbance has been identified as one of the factors influencing waterfowl distribution and habitat use during migration (Madsen 1998, Webb et al. 2010*a*). Disturbance is more likely to affect waterfowl during spring migration compared to other times of the year because of the high energetic requirements associated with migration and subsequent breeding activities (Arzel et al. 2006, Madsen and Fox 1995). Providing areas free from hunting disturbance (refuges) generally causes waterfowl to become concentrated at these sites while avoiding disturbed areas (Giroux and Bedard 1988, Madsen and Fox 1995, Madsen 1998, Evans and Day 2002). Changes in waterfowl distribution caused by hunting disturbance may lead to the underutilization of food resources on disturbed areas, as well as artificially high densities and increased competition in areas free from disturbance (Madsen and Fox 1995).

Mid-continent populations of light geese, composed of lesser snow geese (*Chen caerulescens*) and Ross's geese (*C. rossi*), have grown steadily since the late 1960s and are now estimated at greater than 6 million breeding birds (Abraham et al. 2005). Substantial increases in light goose populations have resulted in destruction of some arctic breeding habitats (Abraham and et al. 2005). Intense grazing of shoots, grubbing of roots and rhizomes by light geese, in conjunction with a short growing season, have led to irreversible vegetation loss, increased soil salinity, erosion, and desertification in

some areas (Srivastava and Jefferies 1996, Abraham and Jefferies 1997, Jefferies and Rockwell 2002). The Light Goose Conservation Order (LGCO) was implemented by the U.S. Fish and Wildlife Service (USFWS) in 1999 in an effort to reduce mid-continent populations of light geese (Abraham et al. 2005, USFWS 2007). The LGCO allows the legal harvest of light geese after March 10th, following closure of all other waterfowl seasons. Prior to enaction of the LGCO, no legal waterfowl hunting occurred after March 10th since the signing of the Migratory Bird Treaty Act in 1918 (USFWS 2007).

Hunting during the LGCO is a potential source of disturbance for non-target waterfowl using the Rainwater Basin (RWB) of Nebraska as a spring stopover site (Webb et al. 2010*a*). Prior to the LGCO, wetland loss combined with annual variation in flooded wetland availability and the movement of millions of light geese into the region contributed to an increase in migratory bird densities on RWB wetlands (Gersib et al. 1989, Bishop and Vrtiska 2008). Hunting disturbance during the LGCO could also potentially contribute to greater waterfowl densities on individual wetlands in the RWB. High waterfowl densities have been suggested to increase avian stress levels and disease susceptibility (Friend 1981, Smith and Higgins 1990, Wobeser 1997, Bishop and Vrtiska 2008). Avian cholera outbreaks are believed to occur when birds become stressed and crowded and have been a major concern for waterfowl managers in the RWB since 1975, when an estimated 25,000 birds died (Zinkl et al. 1977). Hunting disturbance may also lead to waterfowl underutilizing food resources during the LGCO (Madsen and Fox 1995). Food resources on wetlands open to hunting may be abundant, but not fully utilized by migrating waterfowl because disturbance could prevent birds from using these sites (Madsen and Fox 1995). Additionally, hunting during the LGCO in the RWB may

cause waterfowl to use sub-optimal habitat, and disturbed waterfowl may use habitats with food resources that yield less metabolizable energy (Bechet et al. 2004). Underutilization of food resources and use of sub-optimal habitats as a result of hunting disturbance during the LGCO in the RWB both have potential to limit nutrient acquisition during this crucial time period (Madsen and Fox 1995, Bechet et al. 2004, Arzel et al. 2006). Reduced nutrient acquisition could ultimately affect subsequent reproductive output and breeding success of waterfowl using the RWB during spring migration (Madsen and Fox 1995, Mainguy et al. 2002, Bechet et al. 2004).

The LGCO was implemented with caution in the RWB due to considerable concern that hunting disturbance might impact the distribution and behavior of non-target waterfowl species during spring migration (Vrtiska and Sullivan 2009). Current regulations during the LGCO in the RWB limit hunting to four days a week (Saturday, Sunday, Wednesday, and Thursday), and close 16 specific public wetlands to hunting. Hunting is allowed seven days a week after the third week in March, and the LGCO season closes in the RWB during the second week of April. Although regulations were established with the concurrent goals of maximizing light goose harvest and reducing potential impacts of hunting disturbance on non-target species, effects of these regulations on waterfowl distribution in the RWB during the LGCO are still relatively unknown (Vrtiska and Sullivan 2009). Therefore, our objectives for this chapter were to quantify hunter participation during the LGCO and assess how waterfowl distribution may be affected by hunting disturbance during spring migration in the RWB of Nebraska. We surveyed wetlands for the presence of migratory birds and LGCO participants during

spring (mid-February - late March) migrations 2011 and 2012 to evaluate the effects of disturbance caused by the LGCO.

STUDY AREA

The RWB region is recognized as one of the most important waterfowl migration areas in North America (USFWS and Canadian Wildlife Service 1986). The region occupies a 16,000 km^2 area within 21 counties in south-central Nebraska (Bishop and Vrtiska 2008). Wetlands in the RWB are categorized as playas (Smith 2003, LaGrange 2005) and were formed and maintained through a combination of wind deflation and dissolution of subsurface basin material. (Osterkamp and Wood 1987, Gustavson et al. 1995, Reeves and Reeves 1996). Precipitation in the region increases along a gradient from west to east, with mean annual precipitation ranging from 43 cm in Phelps County in the west to 74 cm in Fillmore County in the east (Gilbert 1989). The RWB is located in a semi-arid climate and most wetlands in the region do not receive groundwater inflow, resulting in high annual variation in flooded wetland availability (Brennan et al. 2005, LaGrange 2005, Vrtiska and Sullivan 2009). In years with low precipitation, wetland hydrology is often supplemented by pumping groundwater directly from the Ogallala aquifer on multiple publicly owned wetlands (Smith et al. 1989, Smith and Higgins 1990). Most wetlands in the region can be classified into one of three palustrine emergent wetland hydrologic regimes (Gersib et al. 1989): temporarily, seasonally, or semi-permanently inundated (Cowardin et al. 1979). Current distribution of wetlands in the RWB by hydrologic regime include; 26% temporary, 46% seasonal, and 28% semi-permanent (Smith and Higgins 1990).

Prior to European settlement, the RWB contained an estimated 4,000 naturally occurring wetlands, covering approximately 38,000 ha (Erickson and Leslie 1987). However, Smith and Higgins (1990) estimated only 445 of the original wetlands remained, representing 11% of the original number and 30% of the original wetland area. Of the remaining wetlands, approximately 80% have undergone hydrologic alterations, affecting wetland area, function, and quality for wildlife habitat (Schildman and Hurt 1984, Smith and Higgins 1990, Bishop and Vrtiska 2008). Despite the loss and degradation of RWB wetlands, the area still serves as a major spring staging area for waterfowl in North America (Gersib et al. 1989). Bishop and Vrtiska (2008) estimated approximately 9.8 million waterfowl use the RWB region each year during spring migration. Approximately 50% of the mid-continent population of mallards (*Anas platyrhynchos*) and 30% of the continental population of Northern pintails (*A. acuta*), and an ever-increasing number (> 1.5 million) of light geese use the RWB region during spring migration (Gersib et al. 1989, Krapu et al. 1995, LaGrange 2005, Bishop and Vrtiska 2008, Vrtiska and Sullivan 2009).

METHODS

Wetland Selection

Due to variation in precipitation and wetland availability (Bishop and Vrtiska 2008), we selected study wetlands on an annual basis, assessing potential sites for water using ground surveys in late January/early February 2011and 2012. We paired public wetlands closed to LGCO hunting with either one or two public wetlands open to LGCO hunting (hunting category) based on similarities in wetland area, percent vegetative

cover, and geographic location. Wetland area was visually estimated as a percentage of the hydric footprint containing water and vegetative cover types were determined using methods described by Stewart and Kantrud (1971). We used a total of 22 public wetlands (13 open to hunting and 9 closed to hunting) as study sites over the two years of our study (Figure 2.1).

Hunting Encounters

To quantify hunting participation on wetlands open to hunting during the LGCO, we recorded the number of hunting parties present during each wetland observation. Although study objectives did not include quantifying LGCO participation in non-wetland habitats, if we opportunistically observed hunters in agricultural fields or on non-study wetlands, we recorded the date, location (coordinates and site description), and number of participants. We also opportunistically stopped potential hunters on roads, parking lots, etc. to gather as much information as possible about their hunting behavior for that day, including times and locations of their hunting activities.

Waterfowl Surveys and Statistical Analyses

We quantified waterfowl abundance on study wetlands open and closed to hunting by simultaneously conducting waterfowl surveys on paired wetlands during springs 2011 and 2012. If two wetlands open to hunting were grouped with one wetland closed to hunting, we alternated visits between wetlands open to hunting for that group. After recording all observable hunters present we then surveyed the wetland for waterfowl abundance. We spent approximately 1.5-2 hours at each wetland pair and then moved to another wetland pair following completion of waterfowl surveys; we typically visited 4-5 wetland pairs/day and surveyed each wetland pair approximately 3-4 times per

week. We divided diurnal time period into 4 time intervals; dawn (30 minutes before sunrise-0900), morning (0900-1230), afternoon (1230-1600), and evening (1600-30 minutes after sunset) and attempted to conduct an equal number of observations for each wetland pair/group within these time periods.

During each waterfowl survey we observed study wetlands for the presence of dabbling ducks (*Anas* spp.) and geese (tribe: Anserini). We recorded all waterfowl visible in open water from a pre-determined vantage point(s) and then entered the wetland to visit pre-determined points to detect waterfowl not visible in open water. We used both spotting scopes and binoculars, whichever was most appropriate at the time, to count waterfowl. To ensure consistent sampling effort, number of points within a wetland varied with wetland area: 1 point in wetlands ≤ 5 ha; 2 points in wetlands 5.1-25 ha; 3 points in wetlands 25.1-100 ha; and 4 points in wetlands > 100 ha (Brown and Dinsmore 1986, Webb et al. 2010*a* and *b*). All birds observed while walking between observation points were included in the overall count for that wetland, however, if birds previously counted flew to another part of the wetland they were not included (Fairbairn and Dinsmore 2001, Webb et al. 2010*a* and *b*). In flocks with < 100 birds, individual number and species were recorded; in flocks of > 100 birds, species were recorded and the numbers of birds for each species were visually estimated (Webb et al. 2010*a* and *b*). Flocks of > 100 were estimated based on the following criteria; 100-500 birds were estimated to the nearest 10, 501-2000 birds to the nearest 100, and nearest 1000 for larger flocks.

During each wetland observation we estimated the percent of the wetland containing water (% full) by visually comparing current water levels with aerial

photographs and the extent of the wetland plant boundary (Webb et al. 2010*a*). We used aerial photos in ArcMap (ArcGIS) to construct polygons and calculate the area of each wetland footprint (i.e., area of wetland when 100% full) for all study sites (ESRI 2010). We then used estimated inundated wetland area for each survey to calculate total dabbling duck density as well as densities of mallards and pintails (ducks/ha). We excluded all surveys where we observed zero waterfowl and either ice cover exceeded 90% or if less than 10% of the wetland was inundated at the time of the survey. We also reclassified three study wetlands that were open to hunting in 2012 as closed for data analysis because no hunting encounters were observed on them. The variable hunt day was determined for each waterfowl survey based on the designation of that day being open or closed to hunting. We defined season (early and late) based on the decline of light geese observed on study wetlands. Early season was classified as the time from when surveys began up through the week when greater than 95% of all light geese observed on study wetlands each year had left the RWB region; with late season occurring after the designated week (Webb et al. 2011). Consequently, hunting encounters recorded on study wetlands open to hunting also declined sharply during late season.

We used a generalized linear mixed-model with a Poisson distribution (typical for count data; Bolker et al. 2009) and a multiplicative overdispersion component to test for differences in total dabbling duck densities, as well as individual mallard and pintail densities (Schabenberger 2005). Wetland site was designated as a random residual effect, which is equivalent to using it with the repeated statement in the PROC MIXED procedure in SAS (Schabenberger 2005). We used the generalized mixed-model to test

for the fixed effects of year, hunt category, hunt day, season and all possible interactions (PROC GLIMMIX; SAS Institute Inc. 2010).

For those wetlands open to hunting, we also tested for effects of observed hunting frequency on dabbling duck densities. We calculated mean weekly dabbling duck density for each site open to hunting to account for differences between when surveys were conducted and hunting encounters were recorded at sites. We used a generalized linear mixed-model with a Poisson distribution, a multiplicative overdispersion component, and site as a random residual effect to test for effects of weekly and cumulative hunting encounter frequencies on dabbling duck density at wetlands open to hunting (PROC GLIMMIX; SAS Institute Inc. 2010). For weekly hunting frequency, we tested for differences among sites open to the LGCO among three frequency categories; zero, one and two or more weekly hunting encounters. We classified cumulative hunting encounters at sites open to hunting into five categories; zero, one, two, three-four, and $\geq$ five total hunting encounters. We based cumulative hunting categories primarily on the frequency distribution of cumulative hunting encounters, resulting in a relatively equal sample size among categories. We restricted our analyses of weekly and cumulative hunting encounter frequencies to early season under the assumption that late season densities were more affected by departure of large numbers of dabbling ducks from the region. The ratios of the generalized chi-square statistic to the degrees of freedom were used to evaluate fit of all generalized linear mixed-models. A ratio of approximately 1 indicated variability in our data had been properly modeled, and there was no residual overdispersion (Schabenberger 2005).

We recorded few greater white-fronted geese (*Anser albifrons*; hereafter white-fronted geese) during waterfowl surveys. Therefore, we converted white-fronted goose observations to a qualitative binary response variable (presence/ absence) for each survey (Bewick et al. 2005). If > 1 white-fronted goose was recorded during a survey they were classified as present and if ≤ 1 white-fronted goose was observed we classified them as absent. We used logistic regression to test if wetlands closed to hunting were a significant predictor for the presence of white-fronted geese (PROC LOGISTIC; SAS Institute Inc. 2010). Analysis of white-fronted geese was restricted to early season surveys; if late season surveys were included it would have substantially lowered the presence/absence ratio and decreased the statistical power for detecting a hunting effect (Bewick et al. 2005). Survey data for light geese were extremely variable and were not analyzed. All statistical analyses were performed with SAS software version 9.3 (SAS Institute Inc. 2010), type I error rate was controlled at $\alpha \leq 0.05$ and we report all means ± standard error.

RESULTS

Hunting Encounters

We recorded a total of 168 hunting parties throughout the RWB region during springs 2011 and 2012 (Figure 2.2). The majority of hunting encounters (71%) were recorded in 2011; however, numbers of encounters observed on study wetlands were similar between years. We recorded 70 hunting parties on study wetlands during both years, 38 (54%) in 2011 and 32 (46%) in 2012. Hunting encounters on study wetlands were distributed evenly between weekdays open to hunting (35 encounters) and

weekends open to hunting (35). Total hunting encounters recorded were also distributed relatively equally among the four diurnal time periods; 32% at dawn, 31 % in morning, 27 % in afternoon, and 10% in evening. Of the hunting encounters observed on study wetlands, 81% occurred in Zone 1, while only 19% occurred in Zone 2. Almost all (91%) hunting encounters on study wetlands and in the region (86%) were recorded during early season. We observed hunters on each study wetland classified as open to hunting at least once during early season in both 2011 and 2012.

Waterfowl Surveys

We conducted a total of 541 waterfowl surveys on wetlands open and closed to hunting (223 surveys from 16 February-31 March 2011, and 318 surveys from 21 February-28 March 2012). We removed 32 surveys prior to analyses because we observed no waterfowl during the surveys and wetlands were either ≥ 90% ice cover or ≤ 10% full at the time of the survey. Mean dabbling duck densities were at least two times greater on wetlands closed to hunting, compared to wetlands open to hunting in nearly every week of the early season in both 2011 and 2012 (Figure 2.3). Dabbling duck migration also occurred over a shorter time period in 2012 when compared to 2011; however, the majority of migration and data collection occurred from approximately mid-February to late March in both years of our study (Figure 2.3).

We detected no interactions among independent variables in the analysis of dabbling duck densities (all $F \leq 3.84$, $P \geq 0.067$). Dabbling duck densities were greater on study wetlands during early season ($\overline{x}$ = 174.9 ± 18.6 ducks/ha), compared to late season ($\overline{x}$ = 48.4 ± 7.8 ducks/ha) ($F_{1, 18} = 26.36$, $P < 0.001$). Densities of dabbling ducks were also greater on wetlands closed to hunting ($\overline{x}$ = 171.4 ± 19.2 ducks/ha), compared to

wetlands open to hunting ($\bar{x}$ = 51.3 ± 5.2 ducks/ha) ($F_{1, 17}$ = 21.40, P < 0.001) (Table 2.1). Dabbling duck densities did not differ between hunt day categories ($F_{1, 18}$ = 0.71, P = 0.412) or years ($F_{1, 18}$ = 0.20, P = 0.735).

We detected no interactions among independent variables in the analysis of mallard densities (all $F \leq 1.07$, $P \geq 0.323$). Mallard densities were greater on study wetlands during early season ($\bar{x}$ = 59.7 ± 6.9 ducks/ha), compared to late season ($\bar{x}$ = 7.9 ± 1.5 ducks/ha) ($F_{1, 18}$ = 36.74, P < 0.001). Mallard densities were also greater on wetlands closed to hunting ($\bar{x}$ = 51.1 ± 6.9 ducks/ha), compared to wetlands open to hunting ($\bar{x}$ = 17.6 ± 2.3 ducks/ha) ($F_{1, 17}$ = 10.01, P = 0.006) (Table 2.1). Mallard densities did not differ between hunt day categories ($F_{1, 18}$ = 0.98, P = 0.336) or years ($F_{1, 18}$ = 0.07, P = 0.834).

We detected no interactions in the analysis of pintail densities (all $F \leq 3.52$, $P \geq 0.078$). Pintail densities were greater on study wetlands during early season ($\bar{x}$ = 110.9 ± 12.7 ducks/ha), compared to late season ($\bar{x}$ = 14.3 ± 2.8 ducks/ha) ($F_{1, 18}$ = 34.81, P < 0.001). Densities of pintails were greater on wetlands closed to hunting ($\bar{x}$ = 100.1 ± 12.8 ducks/ha), compared to wetlands open to hunting ($\bar{x}$ = 26.2 ± 3.2 ducks/ha) ($F_{1, 17}$ = 12.02, P = 0.003) (Table 2.1). Pintail densities did not differ between hunt day categories ($F_{1, 18}$ = 1.63, P = 0.217) or years ($F_{1, 18}$ = 0.09, P = 0.819).

We detected no differences in mean weekly dabbling duck densities among weekly hunting frequency categories during early season ($F_{2, 18}$ = 1.04, P = 0.375) (Figure 2.4). Also, mean weekly dabbling duck densities at sites open to hunting did not differ among cumulative hunting encounter categories in early season ($F_{4, 14}$ = 0.44, P = 0.777) (Figure 2.5).

We conducted 290 waterfowl surveys during early season in both years combined and observed a total of 4,286 white-fronted geese. White-fronted geese were observed during 34 of these surveys (18 on closed and 16 on open wetlands) and the maximum number of white-fronted geese recorded for any one survey was 520 birds. Mean number of white-fronted geese observed were 10.7 ± 4.5 and 19.03 ± 6.46 on wetlands closed and open to hunting, respectively. Hunting category was not a predictor for the presence of white-fronted geese ($\chi^2 = 0.056$, $P = 0.813$).

DISCUSSION

Dabbling duck densities were greater on wetlands closed to LGCO hunting during both years of our study. When evaluated separately, mallards and pintails as individual species also exhibited similar responses to LGCO hunting, but this finding is not surprising given these species make up the majority of dabbling ducks using the RWB during spring migration (Gersib et al. 1989, LaGrange 2005, Bishop and Vrtiska 2008). Given our study design in which we simultaneously observed paired wetlands (open and closed to hunting) based on geographic location, wetland area, and vegetative cover, we believe our observed differences in dabbling duck densities are due to hunting disturbance and not differences in habitat quality. Several other studies have also shown local redistribution of waterfowl in relation to hunting disturbance (Giroux and Bedard 1988, Madsen and Fox 1995, Madsen 1998, Evans and Day 2002) and Webb et al. (2010*a*) also reported LGCO hunting category (open to hunting) had a negative effect on dabbling duck abundance in the RWB during years with low wetland availability. However, Webb et al. (2010*a*) did not record hunter activity and designated wetlands as

open or closed to hunting based on regulations for the LGCO in the RWB at the time of data collection. Although our study lacked experimental control of hunting activity on study wetlands (Madsen and Fox 1995, Bregnballe et al. 2004), we verified every wetland classified as open to hunting in our study was hunted at least once during early season when we observed the vast majority of hunting encounters.

The long term population effects of local redistribution caused by LGCO hunting on dabbling ducks is challenging to quantify because migratory birds use a variety of habitats and behavioral strategies to complete their annual life cycle (Owen 1993, Arzel et al. 2006, Drent et al. 2007). During years with spring hunting, greater snow geese (*Chen caerulescens atlantica*) used habitats that yielded less metabolizable energy, which reduced the overall energy intake of geese (Bechet et al. 2004). In the same study area, lowered energy intake reduced lipid and protein reserves of departing greater snow geese during years with spring hunting (Féret et al. 2003). Mainguy et al. (2002) also demonstrated greater snow goose body condition indices and clutch sizes were lower for nesting birds in years with spring hunting. Although dabbling ducks are non-target species, local redistribution caused by hunting disturbance has the potential to negatively impact dabbling duck lipid acquisition during spring migration in the RWB and subsequent nesting efforts. However, cross-seasonal effects of LGCO hunting on non-target species are more challenging to quantify, as dabbling ducks are not colonial breeders like greater snow geese (Mainguy et al. 2002), and are considered income breeders, relying more on nutrient sources collected locally on breeding grounds (Drent et al. 2006, Drent et al. 2007). Pintails collected in the eastern and western RWB in the late 1990s showed no difference in lipid or protein content during spring hunting season,

despite the entire western portion of the RWB being closed to spring hunting activities for light geese (Pearse et al. 2012). However, further investigation into body condition and lipid reserves of dabbling ducks, specifically collected on wetlands open and closed to hunting during the LGCO may provide further insight into the long term effects of redistribution caused by spring hunting in the RWB.

Crowding of waterfowl has been suggested to increase stress levels and disease susceptibility (Friend 1981, Wobeser 1997, Bishop and Vrtiska 2008), and avian cholera has been a major focus of concern for waterfowl managers in the RWB since the mid-1970s (Zinkl et al. 1977). Smith et al. (1990) found a positive relationship between live and dead waterfowl densities (avian cholera deaths) during three out of four years of their study. Mean dabbling duck densities we observed on wetlands closed to hunting during the second week of 2012 (approximately 500 ducks/ha) exceeded or were near mean waterfowl densities reported by Smith et al. (1990) in the three years they found a relationship between bird densities and avian cholera deaths. Dabbling duck densities in our study also do not reflect the possibility of thousands of additional light geese on study wetlands during certain diel periods (i.e. nocturnal roosting). Dabbling duck densities we observed on closed wetlands, in conjunction with results from Smith et al. (1990), suggest that LGCO hunting has the potential to indirectly increase mortality from avian cholera in non-target species, at least during peak migration periods of some years. However, the threshold waterfowl density where crowding starts to have negative impacts on waterfowl using wetlands is poorly understood and likely depends on a variety of factors such as water quality, weather, and time of year (Windingstad et al. 1988, Smith et al. 1990, Blanchong et al. 2006)

We found no effects of hunt day category in our analyses of dabbling ducks as a group, or mallards and pintails as individual species. We also detected no differences in dabbling duck densities among wetlands open to hunting regardless of weekly or cumulative hunting encounters frequency during early season. Shortly after implementation of the LGCO, the Nebraska Game and Parks Commission (NGPC) collected dabbling duck abundance data on RWB wetlands from 2000-2003. In 2001, mallards and pintails were both observed in greater numbers on RWB wetlands on non-hunting days compared to hunting days, and conditions were considered wet, with abundant water throughout the RWB (NGPC, unpublished data). However, availability of flooded wetlands is often limited in the RWB and only 4-23% of wetlands pond water in a given spring (Bishop and Vrtiska 2008). Waterfowl may be less responsive to days closed to hunting in dry years when fewer wetlands are inundated and hunters are more concentrated on wetlands open to hunting. In years with limited flooded wetland availability, disturbance frequency is also likely greater on RWB wetlands open to hunting, and waterfowl may have less opportunity to return to wetlands that are continuously disturbed. The same wetlands have also been closed to hunting during the LGCO in the RWB for over a decade and it is possible that dabbling ducks have become habituated to using these disturbance free sites for the duration of their stop over time. Indeed, Madsen (1998) found that after the establishment of two long term refuges in Danish coastal marshes, the number of mallard bird-days increased by at least a factor of four on both established refuges over a ten year period.

Reaction by waterfowl to intermittent hunting disturbance has varied in several studies (Madsen and Fox 1995). In Mississippi there were no differences in duck

abundance between areas open to fall hunting for 2 or 4 days, despite greater waterfowl food availability on wetlands open to hunting 2 days a week (St. James 2011). Limiting hunting to mornings or evenings was also insufficient to ensure numbers of green-winged teal (*Anas crecca*) were consistent with control areas, which were free from disturbance (Bregnballe et al. 2004). However, individually radio marked mallards in Colorado during fall and winter frequently returned to areas within one day of experimental shooting disturbance (Dooley et al. 2010). Vulnerability to redistribution from hunting disturbance may vary considerably among species, time of year, and with changes in available habitat and food resources (Madsen and Fox 1995, Arzel et al. 2006). For example, in order to avoid human disturbance, Eurasian wigeon (*Anas penelope*) used habitats with food resources of lower nutritional quality, but in the same study brant (*Branta bernicla*) used more energetically profitable habitats, despite being heavily disturbed (Mathers and Montgomery 1997). However, Fox and Madsen (1997) reviewed the literature in Europe where shooting disturbance has been intensely studied and concluded that intermittent hunting is generally not an effective way to minimize hunting disturbance effects on waterfowl abundance. While Fox and Madsen (1997) concurred intermittent hunting improves the ability of a site to maintain greater bird numbers compared to sites with daily shooting activity, they suggested intermittent hunting requires long periods free from disturbance, measured in weeks rather than days.

We found hunting category was not a predictor for the presence of white-fronted geese. However, our statistical power for finding an effect of hunting was relatively low (Bewick et al. 2005), given the low frequency with which we observed white-fronted geese on study wetlands. Several authors reported approximately 90% of the mid-

continent population of white-fronted geese used the RWB as their primary staging area during spring migration (Gersib et al. 1989, LaGrange 2005, Bishop and Vrtiska 2008) and Krapu et al. (2005) estimated peak white-fronted goose abundance of 23,000 and 11,000 on two public wetlands alone in spring 1980. During fall 2011 biologists reported 681,700 mid-continent white-fronted geese for the population estimate in prairie Canada (USFWS 2012). We conducted over 500 surveys on RWB wetlands during the two year study and observed only 3,510 white-fronted geese in 2011 and 1,380 in 2012, leading us to speculate a majority of mid-continent white-fronted geese are no longer using the RWB for spring staging. One of the primary reasons restrictive LGCO regulations were initially implemented in the RWB was to protect white-fronted geese from hunting disturbance due to their close association with light geese during this time period (Mark Vrtiska, NGPC, personal communication). Factors contributing to the apparent decrease in mid-continent white-fronted geese using the RWB for spring staging are unknown. However, the absence of white-fronted geese during spring migration in the RWB has coincided with the westerly movement of millions of light geese into the RWB during spring migration (Vrtiska and Sullivan 2009), a decrease in availability of waste corn in the region (Krapu et al. 2004), and a reduction in stored lipids in white-fronted geese staging in the RWB (Pearse et al. 2011).

MANAGEMENT IMPLICATIONS

Given that dabbling duck densities were greater on wetlands closed to hunting, providing wetlands free from hunting disturbance during the LGCO is likely an important management strategy in the RWB. However, we found no effects of hunt day in our

analyses of dabbling duck densities and no differences in mean weekly dabbling duck densities among wetlands open to hunting regardless of weekly or cumulative hunting encounters frequency. Distribution of the few white-fronted geese still using the RWB for staging did not seem to be affected by hunting disturbance. Given these results, a LGCO season with more allotted hunting time (i.e., open seven days a week) with the current network of closed wetlands remaining in place, will likely have minimal additional impacts on the distribution of non-target waterfowl species using the region for spring staging. An increase in days open to hunting may also increase hunter participation and ultimately aid in the reduction of mid-continent light goose populations. If allotted hunting time during the LGCO is increased, the closure of more public wetlands in the RWB may be warranted, which may help alleviate the potential impacts of crowding and the underutilization of food resources for non-target species in the region. We suggest continually monitoring potential effects of any regulation changes during the LGCO on waterfowl using the RWB during spring migration.

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Table 2.1. Mallard (*Anas platyrhynchos*), Northern pintail (*A. acuta*), and total dabbling duck (*Anas* spp.) densities ($\overline{x} \pm$ SE) on study wetlands open ($n = 234$) and closed ($n = 275$) to hunting during the Light Goose Conservation Order in the Rainwater Basin of Nebraska in springs 2011 and 2012.

	Closed		**Open**			
	(ducks/ha)	**SE**	**(ducks/ha)**	**SE**	***F-value***	***P-value***
Mallards	51.1	6.9	17.6	2.3	10.01	0.006
Pintails	100.1	12.8	26.2	3.2	12.02	0.003
Dabbling Ducks	171.4	19.2	51.3	5.2	21.40	< 0.001

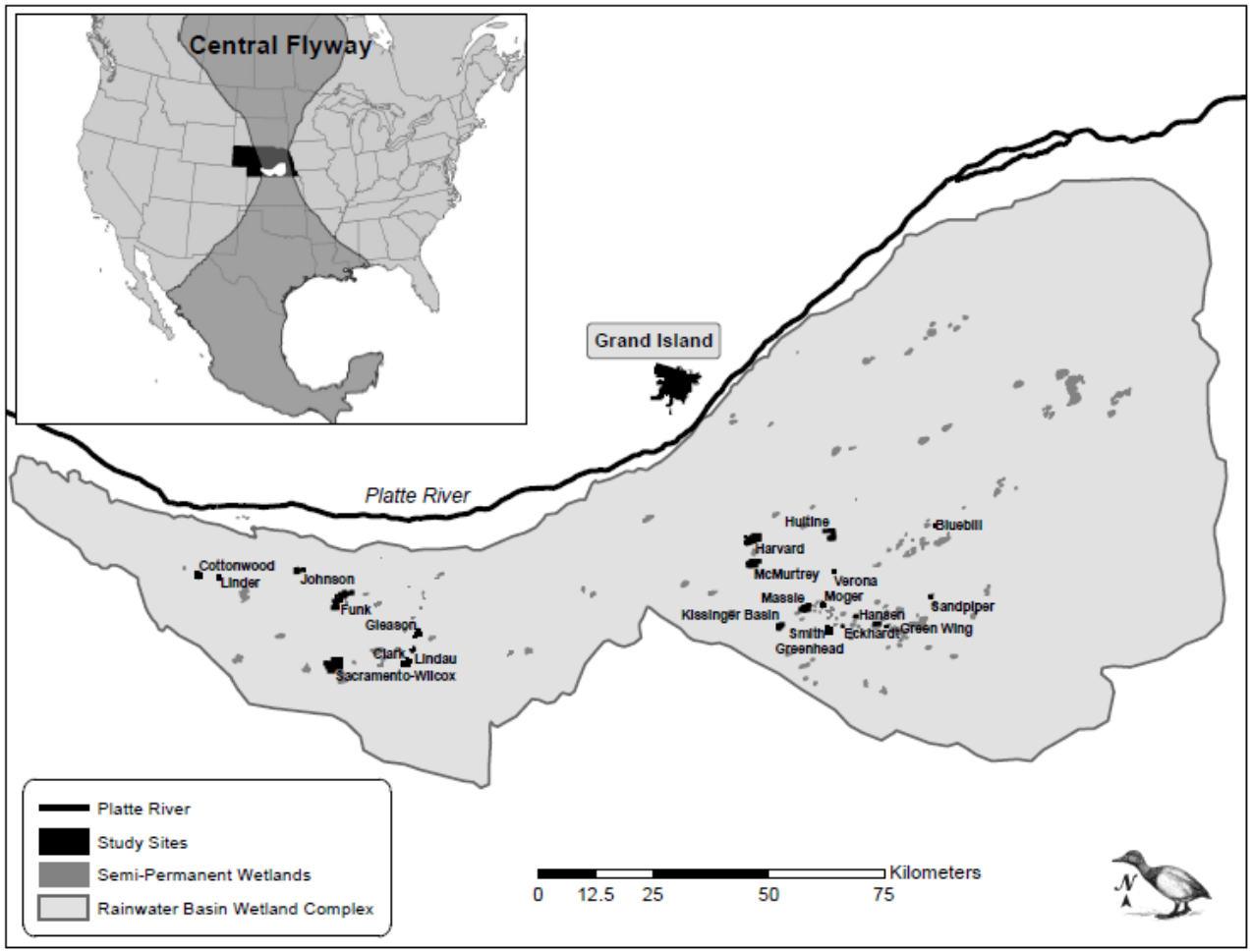

Figure 2.1. Public wetlands (*n*=22; 9 closed and 13 open to hunting) used as study sites to conduct waterfowl surveys and to document hunting participants during the Light Goose Conservation Order in the Rainwater Basin of Nebraska in springs 2011 and 2012.

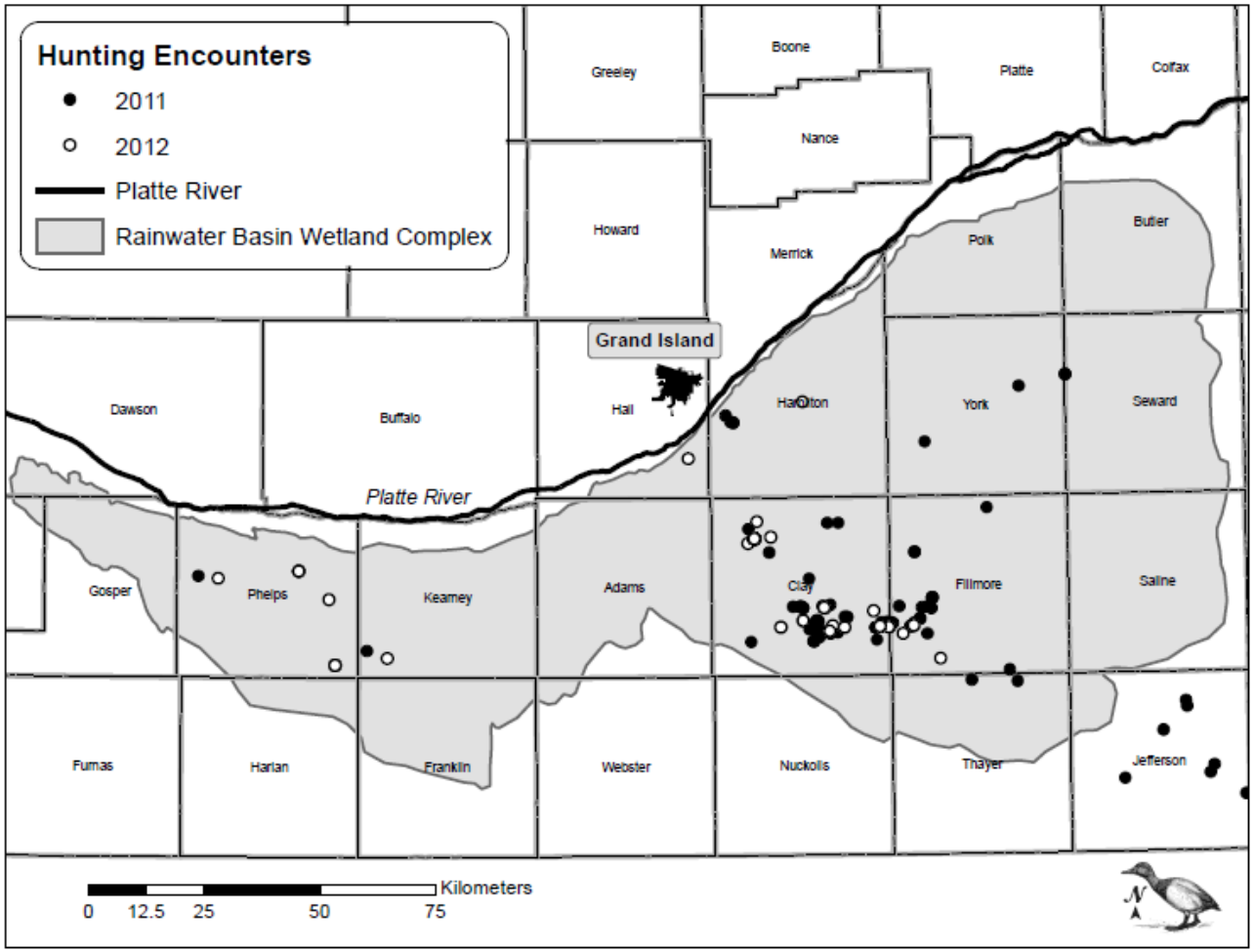

Figure 2.2. Location of hunting encounters recorded during the Light Goose Conservation Order (*n*=168) in the Rainwater Basin of Nebraska in springs 2011 and 2012.

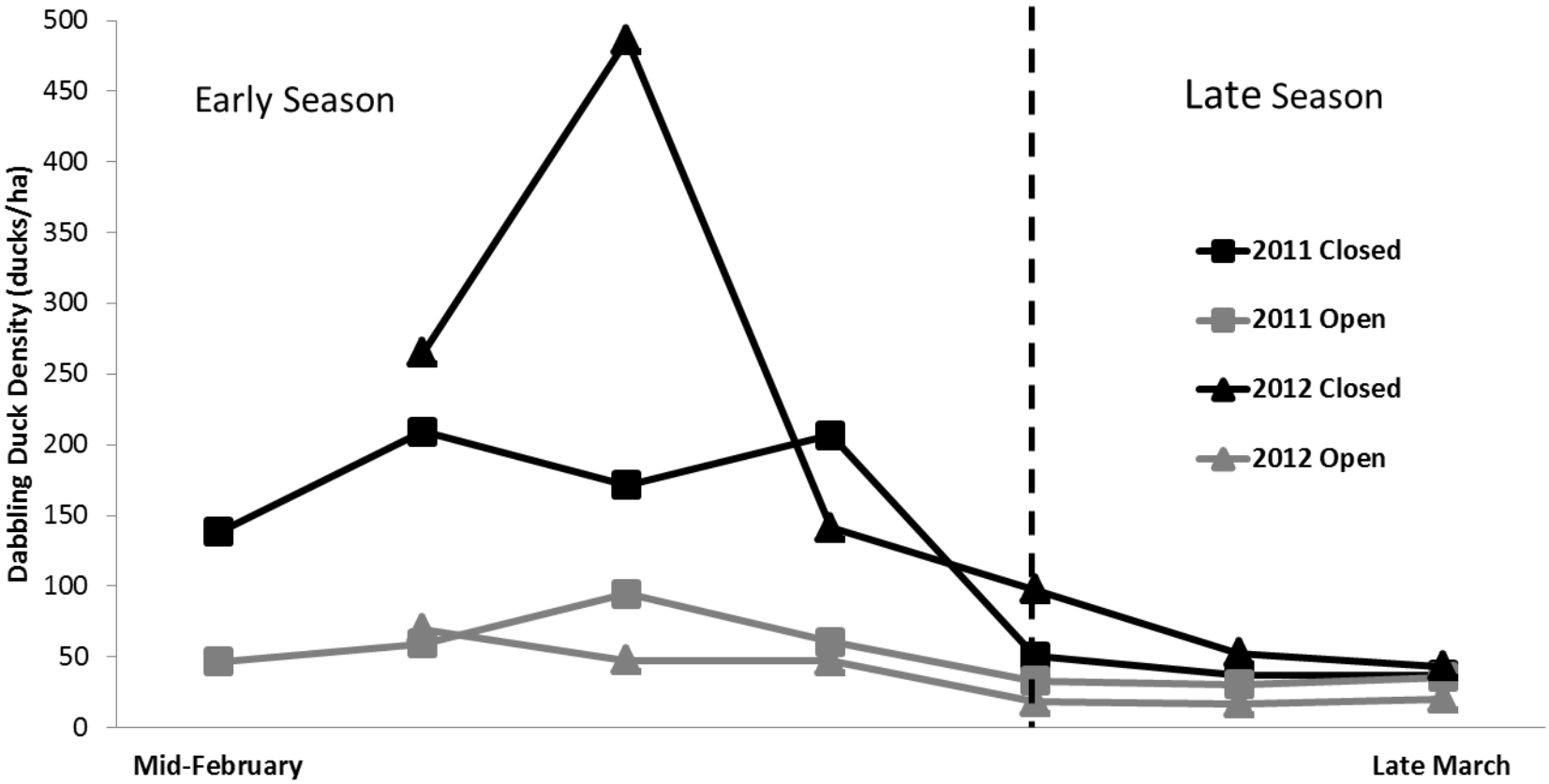

Figure 2.3. Mean weekly dabbling duck (*Anas* spp.) densities in early and late seasons on study wetlands open and closed to hunting during the Light Goose Conservation Order in the Rainwater Basin of Nebraska in spring 2011 (16 February-31 March) and 2012 (21 February-28 March). We classified early season as those weeks prior to the date when greater than 95% of all light geese observed on study wetlands each year had left the RWB region, while we classified late season as all weeks after that date.

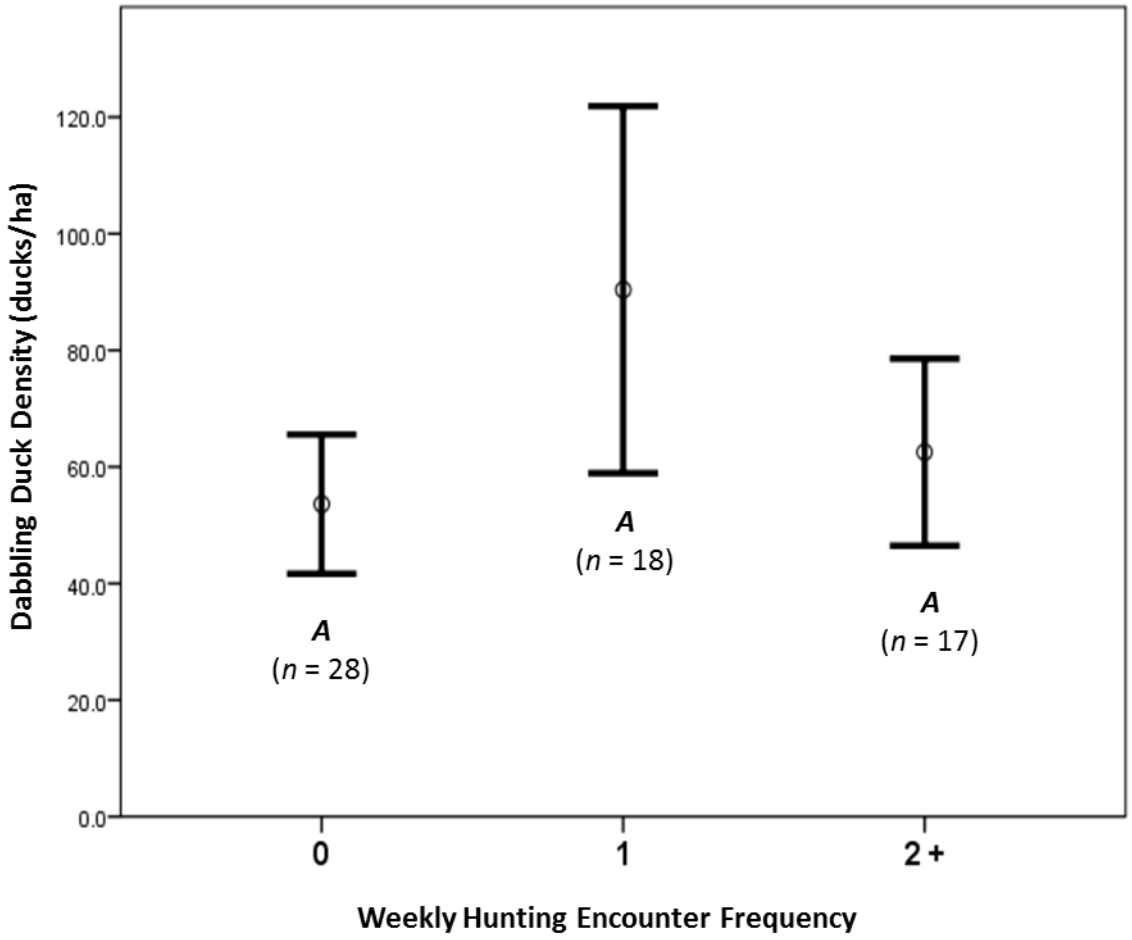

Figure 2.4. Dabbling duck (*Anas* spp.) densities ($\overline{x} \pm$ SE) on wetlands open to hunting based on weekly hunting encounter frequency during the Light Goose Conservation Order in the Rainwater Basin of Nebraska in springs 2011 and 2012. Frequency categories with differing letters are statistically different from others ($\alpha < 0.05$).

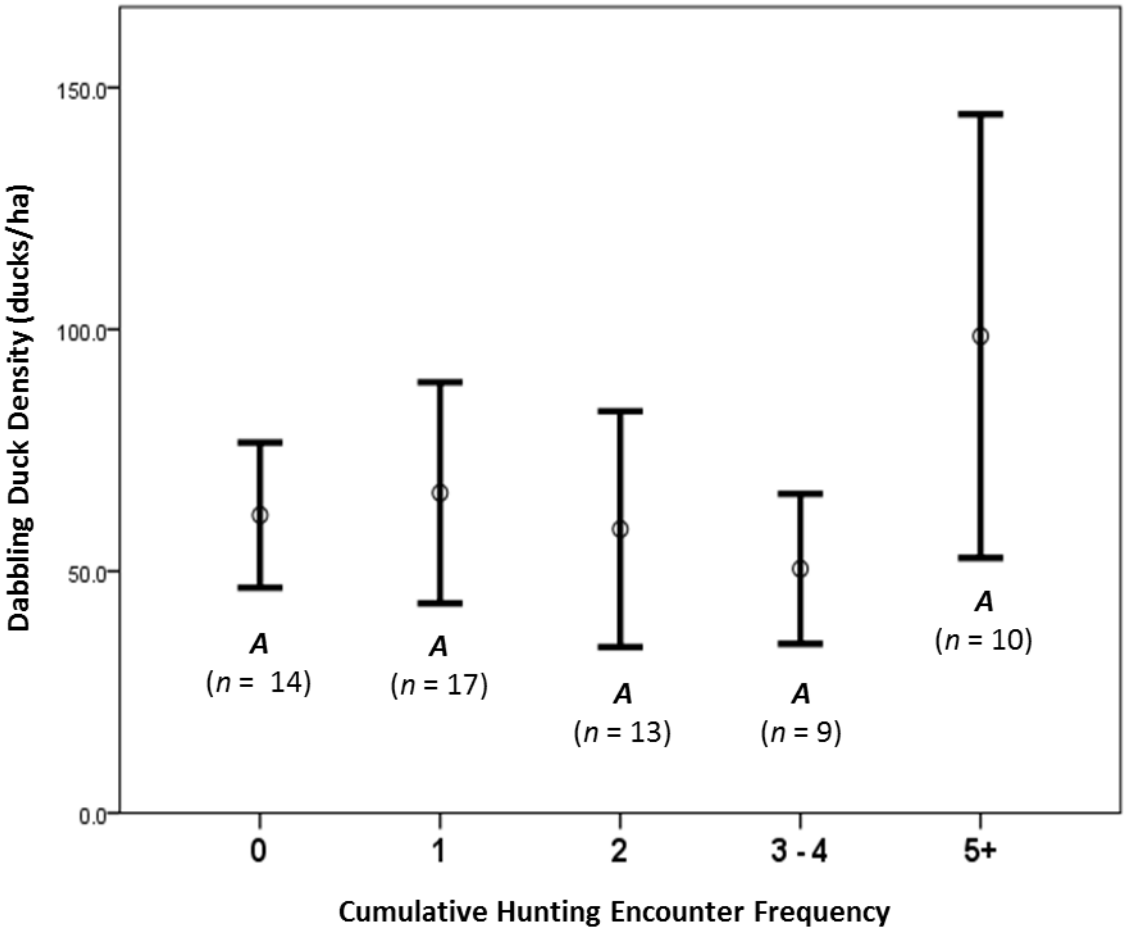

Figure 2.5. Dabbling duck (*Anas* spp.) densities ($\bar{x} \pm$ SE) on wetlands open to hunting based on cumulative hunting encounter frequency during the Light Goose Conservation Order in the Rainwater Basin of Nebraska in springs 2011and 2012. Frequency categories with differing letters are statistically different from others ($\alpha < 0.05$).

CHAPTER III

EFFECTS OF THE LIGHT GOOSE CONSERVATION ORDER ON WATERFOWL BEHAVIOR AND ENERGY EXPENDITURE IN THE RAINWATER BASIN OF NEBRASKA

INTRODUCTION

Shooting disturbance can elicit a stronger response in waterfowl than other disturbance activities and has the potential to affect not only birds being shot at, but also behavior of nearby birds, including non-target species (Belanger and Bedard 1989). Hunting disturbance is also more likely to affect waterfowl during spring migration than other times of the year because of the high energy and food requirements associated with migration and subsequent breeding activities (Madsen and Fox 1995, Arzel et al. 2006). Responses to hunting disturbance include; no reaction, increased alertness and walking/swimming away from the source of disturbance and escape flights (Madsen and Fox 1995). All of these responses to hunting disturbance generally reduce foraging time for waterfowl using disturbed areas (Madsen and Fox 1995). The time it takes birds to resume the activity they were performing (also known as disturbance period) varies among species and the ability to compensate for lost energetic costs incurred by disturbance generally depends on a species' foraging strategy (Belanger and Bedard 1989, Madsen and Fox 1995). Species that require longer feeding times to fulfill daily energy demands are generally less able to energetically compensate for disturbance events (Belanger and Bedard 1989, Madsen and Fox 1995).

Populations of light geese (lesser snow geese [*Chen caerulescens*] and Ross's geese [*C. rossi*]) wintering in the mid-continent U.S. have grown substantially since the 1970s and are now estimated to exceed 6 million breeding birds (Abraham et al. 2005). Destruction of some arctic breeding habitats has resulted from significant increases in mid-continent light goose populations (Abraham and Jefferies 1997). Grubbing of roots and rhizomes and intense grazing of shoots by light geese, coupled with a short growing season, have led to irreversible loss of vegetation, increased soil salinity, erosion, and desertification in some areas (Srivastava and Jefferies 1996, Abraham and Jefferies 1997, Jefferies and Rockwell 2002). The U.S. Fish and Wildlife Service (USFWS) implemented the Light Goose Conservation Order (LGCO) in 1999 in an effort to reduce mid-continent populations of light geese (Abraham et al. 2005, USFWS 2007). No legal waterfowl hunting has taken place after March 10th since the signing of the Migratory Bird Treaty Act in 1918 (USFWS 2007), however the LGCO allows the legal harvest of light geese after this date while all other waterfowl seasons are closed.

Hunting activities during the Light Goose Conservation Order (LGCO) are a potential source of disturbance for non-target waterfowl species during spring migration in the Rainwater Basin (RWB) of Nebraska and may influence bird behavior (Webb et al. 2011). Due to the importance of the RWB as a spring staging area for migratory waterfowl (USFWS and Canadian Wildlife Service 1986), the LGCO was implemented with caution in the region due to concern from managers that hunting disturbance may negatively impact behavior of non-target waterfowl species. Currently, hunting regulations during the LGCO in the RWB limit hunting to four days a week (Saturday, Sunday, Wednesday, and Thursday) and a total of 16 specific public wetlands are entirely

closed to hunting. After the third week of March hunting is allowed seven days a week and the LGCO season closes in the RWB during the second week of April. Regulations were established with the concurrent goal of maximizing light goose harvest, while reducing potential effects of hunting disturbance on non-target species, however, the effect these regulations have on waterfowl behavior in the RWB during the LGCO are still relatively unknown (Vrtiska and Sullivan 2009).

Flight is the most energetically expensive behavior for waterfowl (12.5 × resting metabolic rate) and small increases in flight time can drastically magnify energy expenditure (Wooley 1976, Albright 1983). Belanger and Bedard (1990) estimated hourly energy expenditure for greater snow geese (*Chen caerulescens atlantica*) increased by 5.3% and hourly metabolizable energy intake was reduced by 1.6% as a result of disturbances in which birds flew away, but promptly resumed feeding. In an effort to quantify behavioral differences of waterfowl between wetlands open and closed to hunting during the LGCO in the RWB, Webb et al. (2011) observed a smaller proportion of dabbling ducks (*Anas* spp.) feeding in wetlands open to hunting compared to wetlands closed to hunting or in wetlands open to hunting after the end of the LGCO. Webb et al. (2011) concluded behaviors of non-target species, specifically dabbling ducks, were more affected by hunting disturbance than target species. However, it should be noted that during this study (Webb et al. 2011), data on hunting participation were not recorded for wetlands open to hunting; therefore it was possible wetlands classified as open to hunting did not experience actual hunting pressure. Whether flight time is increased or foraging time is reduced, hunting disturbance during the LGCO in the RWB has the potential to influence behaviors of non-target species, which could limit lipid

acquisition and ultimately affect subsequent reproductive output and breeding success of waterfowl (Madsen and Fox 1995, Mainguy et al. 2002, Bechet et al. 2004, Webb et al. 2011). Therefore, our objectives for this chapter were to quantify hunter participation during the LGCO and assess the effects of hunting disturbance during the LGCO on waterfowl behavior and energy expenditure in the RWB of Nebraska. We surveyed wetlands for the presence of LGCO participants and conducted behavior observations on waterfowl during spring (mid-February - late March) migrations 2011 and 2012 to evaluate the effects of hunting.

STUDY AREA

The RWB region occupies a 16,000 km^2 area that covers 21 counties in south-central Nebraska (Bishop and Vrtiska 2008) and is recognized as one of the most important waterfowl habitat areas in North America (USFWS and Canadian Wildlife Service 1986). Increasing precipitation along a west to east gradient is characteristic of the region, with mean annual precipitation ranging from 43 cm in Phelps County in the west to 74 cm in Fillmore County in the east (Gilbert 1989). The RWB region is positioned in a semi-arid climate and most wetlands are not connected to groundwater inflow, resulting in high annual variation in inundated wetland availability (Brennan et al. 2005, LaGrange 2005, Vrtiska and Sullivan 2009). Wetland hydrology is often supplemented by pumping groundwater directly from the Ogallala aquifer on several publicly owned wetland basins during years with low precipitation (Smith et al. 1989, Smith and Higgins 1990). Classification of most wetlands in the region fall into one of three palustrine emergent wetland hydrologic regimes (Gersib et al. 1989): temporarily,

seasonally, or semi-permanently inundated (Cowardin et al. 1979). Current distribution of wetlands in the RWB by hydrologic regime include; 26% temporary, 46% seasonal, and 28% semi-permanent (Smith and Higgins 1990).

The RWB contained an estimated 4,000 naturally occurring wetlands prior to European settlement, covering approximately 38,000 ha (Erickson and Leslie 1987). However, by the early 1990s, only an estimated 445 of the original wetlands remained, representing 11% of the original number and 30% of the original wetland area (Smith and Higgins 1990). Approximately 80% of the remaining wetlands have undergone hydrologic alterations, which have affected wetland area, function, and quality for wildlife habitat (Schildman and Hurt 1984, Smith and Higgins 1990, Bishop and Vrtiska 2008). The area still serves as a major spring staging area for waterfowl in North America, despite the loss and degradation of RWB wetlands (Gersib et al. 1989). Approximately 9.8 million waterfowl continue to use the RWB region each year during spring migration (Bishop and Vrtiska 2008); including 50% of the mid-continent population of mallards (*Anas platyrhynchos*) and 30% of the continental population of Northern pintails (*A. acuta*; hereafter pintails), and an ever-increasing number (> 1.5 million) of light geese still use this area during spring migration (Gersib et al. 1989, Krapu et al. 1995, LaGrange 2005, Bishop and Vrtiska 2008, Vrtiska and Sullivan 2009).

METHODS

Wetland Selection

Due to variation in precipitation and inundated wetland availability (Bishop and Vrtiska 2008), we selected study wetlands on an annual basis, assessing potential sites for

water using ground surveys in late January/early February 2011and 2012. We paired public wetlands closed to LGCO hunting with either one or two public wetlands open to LGCO hunting (hunting category) based on similarities in wetland area, vegetative cover, and geographic location. Wetland area was visually estimated as a percentage of the hydric footprint containing water and vegetative cover types were determined using methods described by Stewart and Kantrud (1971). We used a total of 22 public wetlands (13 open to hunting and 9 closed to hunting) as study sites over the two years of our study (Figure 3.1)

Hunting Encounters

To quantify hunting participation on wetlands open to hunting during the LGCO, we recorded the number of hunting parties present during each wetland observation. Although study objectives did not include quantifying LGCO participation in non-wetland habitats, if hunters were opportunistically observed in agricultural fields or on non-study wetlands, we recorded the date, location (coordinates and site description), and number of participants. We also opportunistically stopped potential hunters on roads, parking lots, etc. to gather as much information as possible about their hunting activities for that day, including times and locations of their hunting activities.

Focal Behavior and Statistical Analyses

We quantified waterfowl behavior on study wetlands open and closed to hunting by simultaneously conducting focal behavior observations (Altman 1974) at each wetland pair during springs 2011 and 2012 (mid-February - late March). If two wetlands open to hunting were grouped with one wetland closed to hunting we alternated visits between wetlands open to hunting for that group. Focal observations were made for

approximately one hour at each study wetland during which time any hunting encounters were also recorded. After completion of each wetland observation we would move to another wetland pair; we typically completed 4-5 wetland observations per day and surveyed each wetland pair approximately 3-4 times per week. We divided the diurnal time period into 4 intervals; dawn (30 minutes before sunrise-0900), morning (0900-1230), afternoon (1230-1600), and evening (1600-30 minutes after sunset) and attempted to collect an equal number of focal observations for each species and each study wetland within these time periods.

We conducted focal observations on lesser snow geese and greater white-fronted geese (*Anser albifrons*; hereafter white-fronted geese) as well as pintails and mallards. We attempted to conduct an equal number of observations between adult and juvenile geese and between male and female dabbling ducks at each study wetland and for each time period. We observed birds with spotting scopes from a vantage point that permitted an unobstructed view of the study wetland and attempted to limit disturbance to waterfowl, so as to not influence their behavior. A bird of each species was randomly selected by bumping the spotting scope and the next bird in view was observed for 5 minutes, with behavior recorded every 10 seconds. We classified behaviors into 1 of 7 categories (following Davis and Smith 1998, Jorde et al. 1984): resting, feeding, locomotion, maintenance, alert, courtship, and aggression. Age of geese and the sex of dabbling ducks were recorded for each observation.

Prior to analysis we removed any focal observations with behaviors recorded for < 50% of the designated 5 minute sampling period, which usually occurred when a focal bird was lost from sight (Jónsson and Afton 2009). Frequency of each behavior was

converted to a proportion of the overall observations and the duration of observations was therefore not a factor in analyses. We also aggregated behavior data for mallards and pintails into the following categories: resting, feeding, locomotion, maintenance (maintenance, alert), and social (courtship, aggression) to facilitate development of energy expenditure models (McKinney and McWilliams 2005). Courtship and aggression behaviors for geese were combined into one category (social) because the two behaviors combined comprised < 5% of observed behaviors. We also reclassified three study wetlands that were open to hunting in 2012 as closed for data analysis because no hunting encounters were observed on them. The variable hunt day was determined for each focal observation based on the designation of that particular day being open or closed to LGCO hunting. We defined season (early and late) based on the temporal decline of light geese observed on study wetlands. We classified early season as those weeks prior to the date when greater than 95% of all light geese observed on study wetlands each year left the RWB region, while late season was considered all weeks after that date (Webb et al. 2011). Consequently, hunting encounters recorded on study wetlands also declined sharply during late season. We also speculated that differences in waterfowl densities (see Chapter II) recorded on study wetlands during early and late seasons may be influencing waterfowl behaviors as well.

We used multivariate analysis of variance (MANOVA) to test for differences in overall behaviors (Davis and Smith 1998, Webb et al. 2011). Multivariate analysis accounts for correlation among multiple dependent variables and is usually more powerful than a series of separate analysis of variances (ANOVA) (Zar 1999). Additionally, the *F* test in MANOVA is robust to non-normality, if the non-normality is

caused by skewed data distribution, rather than outliers (Finch 2005). We tested for effects of year, season, hunt category, hunt day and all possible interactions on behaviors of mallards and pintails combined (hereafter; dabbling ducks, PROC GLM; SAS Institute Inc. 2010). We also evaluated effects of species, season, and hunt category and all possible interactions on goose behaviors (PROC GLM; SAS Institute Inc. 2010). We used Wilks' lambda (λ) as the test criterion for all MANOVA models. Following a significant MANOVA we used separate ANOVAs to examine differences in individual behaviors among independent variables (PROC GLM; SAS Institute Inc. 2010).

Hourly Energy Expenditure and Statistical Analyses

We used focal behavioral observations to estimate hour energy expenditure (*HEE*) for mallards and pintails using similar methods as Albright (1983) and Jones (2012) with the following equation:

$$HEE = \sum_{i=1}^{n} \left[\left((RMR\ x\ ai) + CT\right) x\ Ti\right] \quad (1)$$

where *RMR* = resting metabolic rate (kj/bird/hour), a_i = activity specific factorial increase in RMR for the i^{th} behavioral activity, *CT* = cost of thermoregulation at a specified temperature (kj/bird/hour), T_i = proportion of time engaged in the i^{th} behavioral activity, and all values are summed across behaviors *(i)* to derive an estimate of total energy expenditure (kj/bird/hour) for each individual observation. We then multiplied each 5 minute estimate of energy expenditure by 12 to calculate *HEE.*

We estimated *RMR* for males and females of both species using an allometric equation derived by Miller and Eadie (2006):

$$RMR = aMass^{b} \quad (2)$$

where a = a mass proportionality coefficient, *Mass* = body mass (kg), and b = slope of the regression line on a log scale. We used the predicted a and b constants based on the allometric relationships reported for the group "dabbling ducks" (a = 457, b = 0.77; Miller and Eadie 2006). We used body masses of mid-winter mallards (female = 1.096 kg, male = 1.246 kg) and pintails (female = 0.887 kg, male = 1.006 kg) previously reported by Drilling et al. (2002) and Austin and Miller (1995). We used values derived by Wooley (1976) for activity-specific factorial increases in *RMR* (a_i) as follows: 1.2 for resting, 1.7 for feeding, 2.2 for locomotion, 2.4 for social activities, and 2.1 for maintenance.

We calculated the cost of thermoregulation similar to Jones (2012) using the following equation:

$$CT = m_c * \Delta T_{LCT-Twc} \quad (3)$$

where m_c is the slope of increasing metabolic energy below the lowest critical temperature (*LCT*) which we derived from Wooley and Owen (1977), and $\Delta T_{LCT-Twc}$ is the difference between wind chill temperature from the lowest critical temperature. If wind chill temperature was above the LCT we assumed that the cost of thermoregulation was zero (Wooley and Owen 1977). We estimated the LCT for each species and sex using the empirical relationship derived by Kendeigh (1977) for non-passerines:

$$LCT = 47.2M^{-0.18} \quad (4)$$

where LCT is in °C and M is body mass in grams. Estimated LCTs were similar between species and sexes, ranging from a high of 13.9 °C for female pintails of to a low of 13.08 °C for male mallards. Therefore, we used a constant LCT of 13.0 °C for all observations, regardless of species or sex. We used ANOVA with the independent variables of sex,

season, hunting category, hunt day, and all possible interactions to test for effects on *HEE* for both mallards and pintails (PROC GLM; SAS Institute Inc. 2010). All statistical analyses were performed with SAS software version 9.3 (SAS Institute Inc. 2010), type I error rate was controlled at $\alpha \leq 0.05$ and we report all means ± standard error.

RESULTS

Hunting Encounters

We recorded a total of 168 hunting parties throughout the RWB region during springs 2011 and 2012 (Figure 3.2). The majority of hunting encounters (71%) were observed in 2011; however, encounters recorded on study wetlands were similar among years. During 2011 and 2012 we observed 70 hunting parties on study wetlands, 38 (54%) in 2011, and 32 (46%) in 2012. Hunting encounters on study wetlands were distributed evenly between weekdays open to hunting (35 encounters) and weekends open to hunting (35). Total hunting encounters recorded were also distributed relatively equally among the four diurnal time periods; 32% at dawn, 31 % in morning, 27 % in afternoon, and 10% in evening. Of the hunting encounters observed on study wetlands, 81% occurred in Zone 1, while only 19% occurred in Zone 2. We recorded 91% of study wetland hunting encounters and 86% of all encounters in the region during the early season. Every study wetland classified as open to hunting was hunted at least once during early season in both 2011 and 2012.

Focal Behavior

We recorded 2,947 focal observations in springs 2011 and 2012 (1,253 mallards, 1,307 pintails, 210 snow geese, and 177 white-fronted geese). We detected a 3-way

interaction between year, season, and hunting category in our initial analysis of dabbling duck behaviors (Wilks' $\lambda = 0.99$, $P = 0.002$). Analyzing behaviors separately by year, we detected two-way interactions between hunting category and season for both 2011 (Wilks' $\lambda = 0.98$, $P = 0.025$), and 2012 (Wilks' $\lambda = 0.99$, $P = 0.026$). Consequently, we tested for the main effects of hunting category by season and year in our final analysis of dabbling duck behaviors.

In 2011, overall dabbling duck behaviors differed between hunting categories during early season (Wilks' $\lambda = 0.95$, $P < 0.001$), but not during late season when hunting disturbance subsided (Wilks' $\lambda = 0.99$, $P = 0.824$). Dabbling ducks spent more time feeding in wetlands closed to hunting ($\overline{x} = 21\% \pm 0.02$), compared to wetlands open to hunting ($\overline{x} = 11\% \pm 0.02$) during early season 2011 ($F_{1, 415} = 11.53$, $P \leq 0.001$) (Figure 3.3). Dabbling ducks also spent less time resting in wetlands closed to hunting ($\overline{x} = 29\% \pm 0.03$), compared to wetlands open to hunting ($\overline{x} = 46\% \pm 0.02$) during early season 2011 ($F_{1, 415} = 20.20$, $P \leq 0.001$) (Figure 3.3). We found no effects of hunt day or hunt day × hunt category interactions during early or late season for dabbling duck behaviors in 2011 (all Wilks' $\lambda \geq 0.98$, $P \geq 0.118$).

In 2012, hunting category had an effect on dabbling duck behaviors in both early (Wilks' $\lambda = 0.95$, $P < 0.001$) and late seasons (Wilks' $\lambda = 0.95$, $P < 0.001$). During early season, dabbling ducks spent more time feeding in wetlands open to hunting ($\overline{x} = 37\% \pm 0.02$), compared to wetlands closed to hunting ($\overline{x} = 26\% \pm 0.01$) ($F_{1, 1085} = 22.55$, $P < 0.001$) (Figure 3.4). Dabbling ducks also spent less time resting in wetlands open to hunting ($\overline{x} = 29\% \pm 0.02$) in comparison to wetlands closed to hunting ($\overline{x} = 35\% \pm 0.03$) during early season 2012 ($F_{1, 1085} = 5.03$, $P = 0.025$) (Figure 3.4). In late season 2012,

dabbling ducks still spent more time feeding in wetlands open to hunting ($\bar{x}$ = 33% ± SE 0.03), compared to wetlands closed to hunting ($\bar{x}$ = 26% ± 0.02) ($F_{1, 665}$ = 4.23, P = 0.040) (Figure 3.4). Dabbling ducks also spent less time in maintenance activities on wetlands open to hunting during late season in 2012 ($\bar{x}$ = 12% ± 0.01), compared to wetlands closed to hunting ($\bar{x}$ = 21% ± 0.01) ($F_{1, 665}$ = 18.06, P < 0.001) (Figure 3.4). We found no effects of hunt day or hunt day × hunt category interactions in early or late season for dabbling duck behaviors in 2012 (all Wilks' $\lambda \geq 0.99$, $P \geq 0.218$).

There was a 3-way interaction between species, season, and hunting category in our initial analysis of goose behavior (Wilks' λ = 0.95, P = 0.011). Evaluating behaviors separately by species, we detected two-way interactions between hunting category and season for both snow geese (Wilks' λ = 0.93, P = 0.037) and white-fronted geese (Wilks' λ = 0.91, P = 0.009). Overall behaviors of white-fronted geese did not differ between hunting categories in early season (Wilks' λ = 0.93, P = 0.156) or late season (Wilks' λ = 0.82, P = 0.069) (Figure 3.5). Snow goose behaviors did not differ between hunting categories during early season (Wilks' λ = 0.97, P = 0.380), but overall behavior differed during late season (Wilks' λ = 0.77, P = 0.020) (Figure 3.6). Snow geese spent more time in locomotion on wetlands open to hunting ($\bar{x}$ = 26% ± 0.07) during late season compared to wetlands closed to hunting ($\bar{x}$ = 6% ± 0.01) ($F_{1, 54}$ = 14.73, P = 0.020) (Figure 3.6).

Hourly Energy Expenditure

We detected no interactions among independent variables in our initial analyses of *HEE* for mallards (all $F \leq 2.41$, $P \geq 0.121$) or pintails (all $F \leq 2.76$, $P \geq 0.097$). There was no difference in *HEE* between hunting categories detected for pintails ($F_{1, 1306}$ =

0.24, $P = 0.627$) (Figure 3.7). However, *HEE* for mallards was greater on wetlands closed to hunting ($\bar{x}$ = 38.94 ± 0.31 kj/bird/hr), compared to wetlands open to hunting ($\bar{x}$ = 37.87 ± 0.32 kj/bird/hr) ($F_{1, 1252} = 6.24$, $P = 0.013$) (Figure 3.7). *HEE* was also greater in early season for both mallards ($\bar{x}$ = 40.31 ± 0.29 kj/bird/hr) and pintails ($\bar{x}$ = 34.91 ± 0.24 kj/bird/hr), compared to late season (mallard $\bar{x}$ = 35.97 ± 0.33 kj/bird/hr and pintail $\bar{x}$ = 31.85 ± 0.30 kj/bird/hr) (both $F \geq 70.58$, $P < 0.001$). *HEE* was greater for both male mallards ($\bar{x}$ = 40.86 ± 0.32 kj/bird/hr) and pintails ($\bar{x}$ = 35.97 ± 0.28 kj/bird/hr), compared to females (mallard $\bar{x}$ = 36.15 ± 0.29 kj/bird/hr and pintail $\bar{x}$ = 31.51 ± 0.23 kj/bird/hr) (both $F \geq 92.87$, $P < 0.001$) (Figure 3.7). Hunt day did not have an effect on mallard ($F_{1, 1252} = 1.74$, $P = 0.189$), or pintail ($F_{1, 1306} = 1.65$, $P = 0.199$) *HEE* (Figure 3.7).

DISCUSSION

Hunting disturbance possibly reduced foraging time for dabbling ducks in early season 2011 on wetlands open to hunting, which is further supported by our results of no difference in overall behaviors among hunting categories in late season of the same year, when hunting encounters drastically declined on study wetlands. Our late season behavior results also indicate potential differences in habitat among study sites were not likely responsible for observed differences in dabbling duck behaviors between hunting categories in early season 2011. In 2012 dabbling ducks spent more time foraging in both early and late seasons in wetlands open to hunting, indicating potential differences in habitat quality may have influenced our results for dabbling duck behavior this year. Migration chronology occurred over a shorter time frame in 2012 and with individual

birds spending less time in the RWB area, it is possible hunting disturbance may not have affected dabbling duck behavior this year.

Webb et al. (2011) also observed a smaller proportion of dabbling ducks feeding in wetlands open to LGCO hunting, compared to wetlands closed to hunting in the RWB. Several others studies similarly reported reduced foraging time for waterfowl as a result of hunting disturbance (Belanger and Bedard 1989, Belanger and Bedard 1990, Fox et al. 1993, Riddington et al. 1996). However, others found contradictory results in relation to foraging time and hunting disturbance. During fall hunting season, Gadwalls (*Anas strepera*) and mottled ducks (*A. fulvigula*) spent more time feeding, alert, and in locomotion and less time loafing on hunted areas compared to non-hunted areas in Louisiana (Paulus 1984, Paulus 1986). Generally, the longer foraging time a species requires to fulfill its daily energy demands, the less able it is to nutritionally compensate for hunting disturbance (Madsen and Fox 1995). Both gadwalls and mottled ducks are known to predominantly forage on wetlands food items (Bellrose 1980, Paulus 1982), thus may spend much of the day foraging in wetlands and be unable to compensate for lost feeding time from hunting disturbance (Madsen and Fox 1995). In our study we recorded behavior data on species that have been known to supplement their diets with waste corn while staging in the RWB (Jorde et al. 1984, Krapu et al. 1995, Pearse et al. 2011) and we frequently observed mallards and pintails feeding in agriculture fields near study sites, particularly during early season when temperatures were at or below freezing temperature. Pearse et al. (2011) reported diets of pintails collected on RWB wetlands were composed of 54% corn. If mallards and pintails are supplementing their diets with high energy waste corn, they may need to forage less in wetlands while staging in the

RWB and perhaps more easily compensate for lost foraging time due to hunting disturbance (Baldassarre et al. 1983, Baldassarre and Bolen 1984). However, even if high energy corn is substituted in the diet of dabbling ducks while staging in the RWB, a diet of exclusively corn is nutritionally inadequate, especially for females preparing for later reproductive efforts (Loesch and Kaminski 1989). In addition, mallards and pintails increase consumption of macro-invertebrates prior to spring migration and likely continue this foraging strategy during spring staging as well (Heitmeyer 1985, Miller 1987, Tidwell et al. 2013). Therefore it is essential that dabbling ducks are provided foraging opportunities in RWB wetlands that are free from hunting disturbance.

The long term population effects of reduced foraging time caused by LGCO hunting on dabbling ducks are challenging to quantify, as they are considered income breeders that rely more on nutrient sources collected locally on breeding grounds for egg production (Drent et al. 2006, Drent et al. 2007). The final link between body condition and nutrient reserves at staging sites and subsequent breeding success is also poorly understood in dabbling ducks (Arzel et al. 2006). Although we documented reduced foraging time in relation to hunting disturbance for dabbling ducks during one year of our study, we did not assess whether reduced foraging activity influenced body condition of dabbling ducks using wetlands open to hunting that year. In our study we had no measurement of food availability, estimates of foraging efficiency (Reinecke et al. 1989), or food depletion rates (Greer et al. 2009), which ultimately influence energy intake for foraging waterfowl (Bechet et al. 2004). Bechet et al. (2004) was able to estimate hourly metabolizable energy gain (HME) based on time spent foraging in greater snow geese that could potentially offset energy losses from disturbance, but this was done in areas

where geese fed solely in monotypic stands such a *Scirpus* and *Spartina* marshes. It would be much more challenging to estimate dabbling duck energy intake based on time spent foraging in RWB wetlands with often diverse plant and invertebrate communities (Gordon et al. 1990, LaGrange 2005, Tidwell et al. 2013). In the RWB, pintails collected in the eastern and western portions of the region in 1998-1999 showed no difference in lipid or protein content during spring hunting season, despite the closure of the entire western portion to spring hunting activities for light geese (Pearse et al. 2012). However, further investigation into body condition and lipid reserves of dabbling ducks, specifically collected on wetlands open and closed to hunting during the LGCO may provide further insight into the long term effects of reduced foraging time as the result of spring hunting on RWB wetlands.

The behaviors of both white-fronted geese and snow geese did not differ between wetlands open and closed to hunting in early season when the majority of hunting encounters occurred on study sites. Webb et al. (2011) also concluded behaviors of non-target species, specifically dabbling ducks, were more affected by hunting disturbance than target species and our results suggest these findings. However, our sample size for behavioral observations of both white-fronted geese and snow geese was relatively low compared to dabbling duck sample size. Diets of snow geese and white-fronted geese staging the RWB consist of > 95% corn (A. Pearse, Northern Prairie Wildlife Research Center, unpublished data), and differences in behavior, especially foraging rates, for geese would likely not be affected by hunting disturbance on RWB wetlands. Although overall snow goose behavior did not differ between hunting categories, snow geese spent considerably more time in alert behavior on both wetlands open and closed to hunting

than did white-fronted geese, which was likely the result of continual hunting pressure during winter and spring migration. Increased time in alert activities potentially reduced foraging time for snow geese, but these effects could be considered a collateral benefit in the effort to reduce mid-continent light goose populations (USFWS 2007).

Several studies have related the effects of anthropogenic activities to energy expenditure in waterbirds (Belanger and Bedard 1990, Schummer and Eddleman 2003, Bechet et al. 2004, Klaassen et al. 2006). In our study we found no difference in energy expenditure for pintails between wetlands open and closed to hunting. Mallards had greater energy expenditure on wetlands closed to hunting, compared to wetlands open to hunting; therefore, we could not attribute greater energy expenditure to hunting disturbance. Schummer and Eddleman (2003) also reported no differences in energy expenditure for American coots (*Fulica american*) between undisturbed and disturbed periods. However, several studies reported greater energy expenditure from hunting disturbance as the result of increased flight time (Belanger and Bedard 1990, Bechet et al. 2004, Jones 2012). Our energy models do not account for energy expended during flight, which is the most energetically expensive (12.5 × Resting Metabolic Rate) behavior, based on estimates derived by Wooley (1976). Flight time is often difficult to account for and is frequently underestimated in time activity budgets (Paulus 1988). Accounting for energy expended during flight increased daytime energy expenditure estimates for mallards wintering in Nebraska by 38% (Jorde et al. 1984). Jones (2012) also reported greater energy expenditure for American black ducks (*Anas rubripes*), compared to previous studies by accounting for more flight activity. We speculate inclusion of flight activity during behavior observations in our study would have resulted in greater *HEE*

estimates and perhaps made potential differences in energy expenditure on wetlands open and closed to hunting easier to detect.

MANAGEMENT IMPLICATIONS

Foraging time for dabbling ducks may be reduced in some years on wetlands open to hunting during the LGCO (Webb et al. 2011). As a result, providing disturbance-free wetlands that offer foraging opportunities on important macro-invertebrates and natural plant seeds for dabbling ducks is likely an important management strategy in the RWB. However, we found no effects of hunt day in our analyses of dabbling duck behaviors or *HEE*. We also found no effects of LGCO hunting on the behaviors of white-fronted geese. Given these results, if the current network of closed wetlands remains, a LGCO season with increased allotted hunting time (i.e., open seven days a week), will likely have minimal additional impacts on the behaviors of non-target waterfowl species using the region for spring staging. Providing more hunting time may also increase hunter participation and ultimately aid in the reduction of mid-continent light goose populations. If allotted hunting time during the LGCO is increased, managers may also consider the closure of additional public wetlands in the RWB to provide additional disturbance-free sites for non-target waterfowl species for resting and foraging. We suggest continually monitoring potential effects of any regulation changes during the LGCO on waterfowl using the RWB for spring staging.

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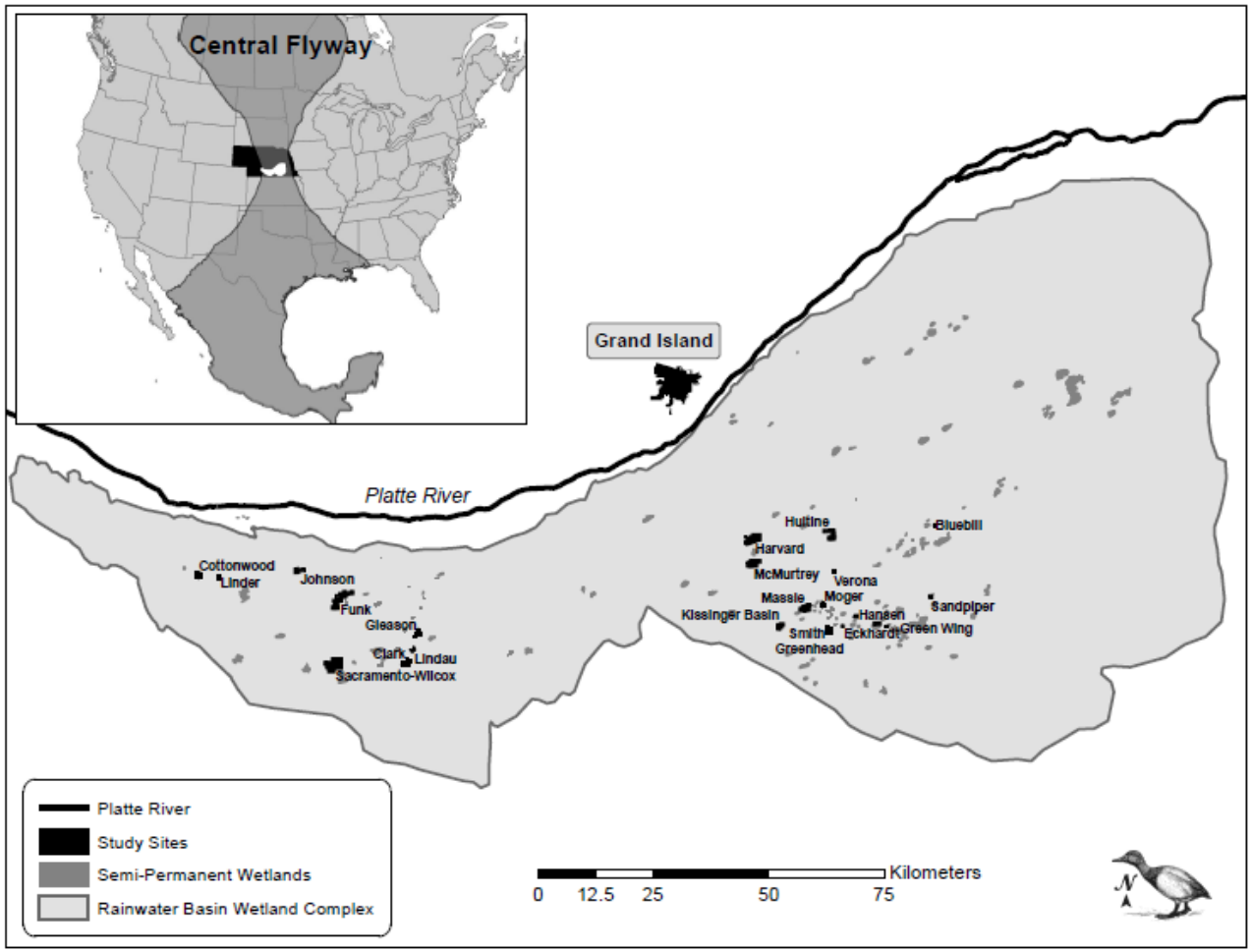

Figure 3.1. Public wetlands (*n*=22; 9 closed and 13 open to hunting) used as study sites to conduct waterfowl behavior observations and to document hunting participants during the Light Goose Conservation Order in the Rainwater Basin of Nebraska in springs 2011 and 2012.

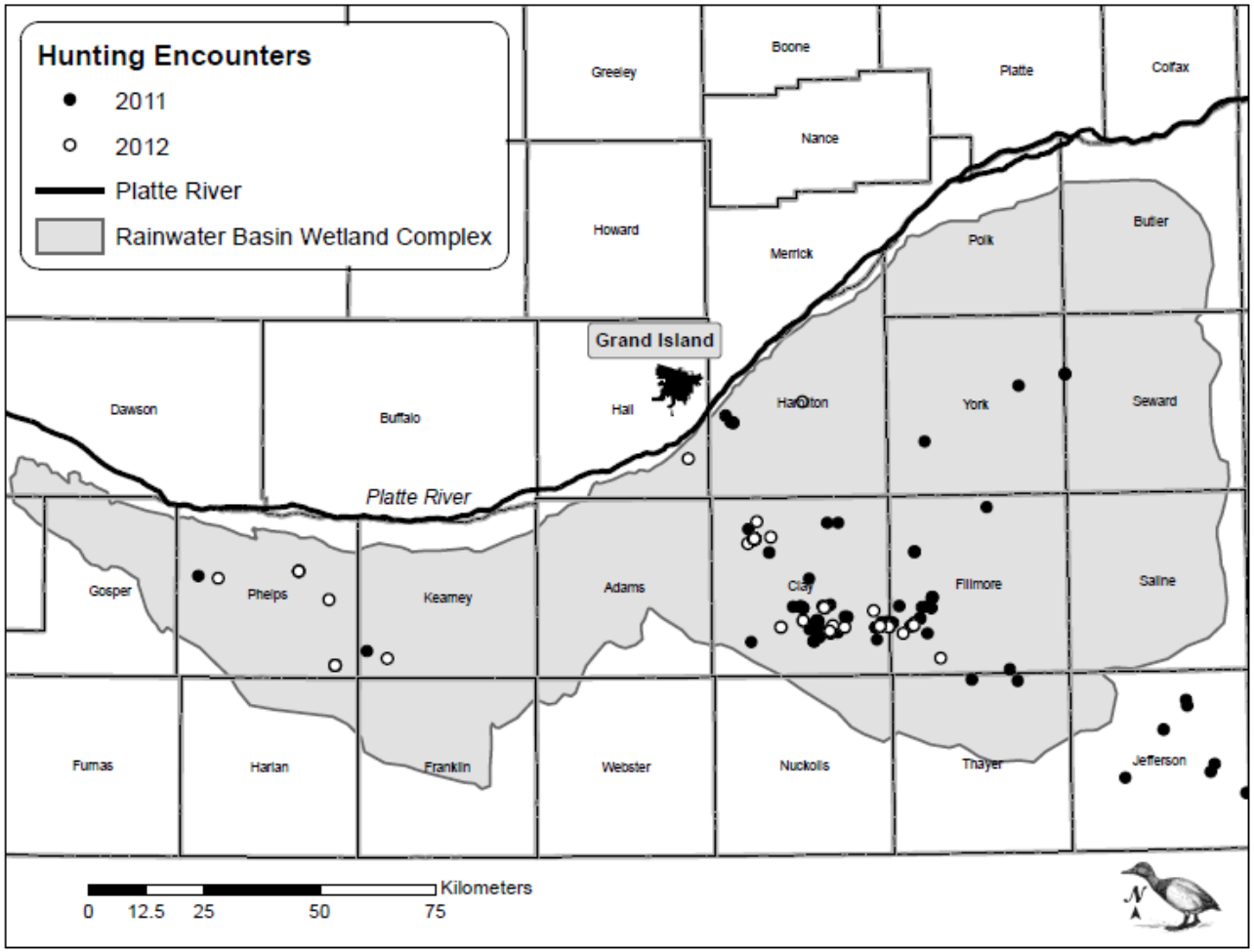

Figure 3.2. Location of hunting encounters recorded during the Light Goose Conservation Order (*n*=168) in the Rainwater Basin of Nebraska in springs 2011 and 2012.

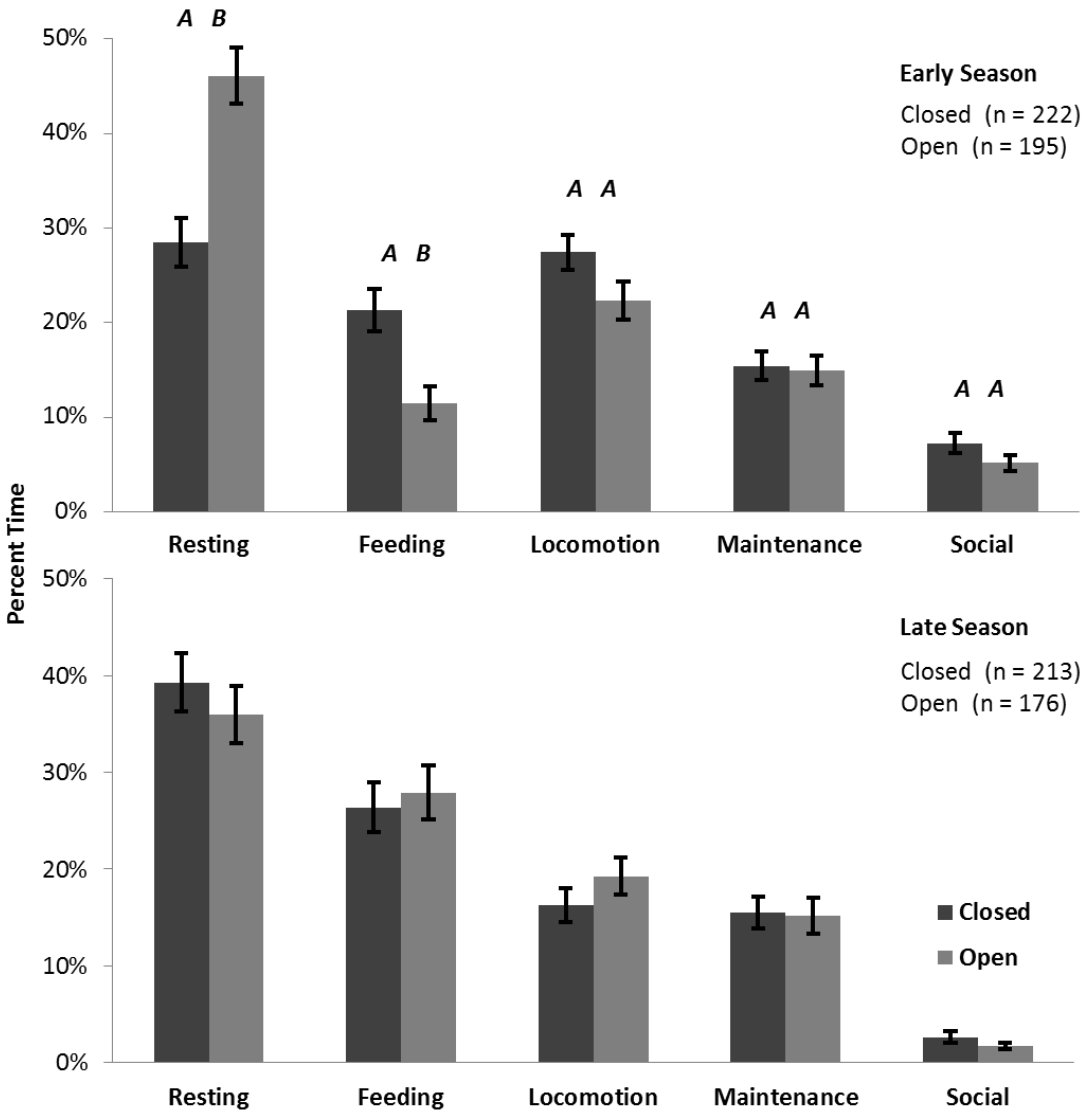

Figure 3.3. Percent time ($\bar{x}$ ± SE) spent by mallards (*Anas platyrhynchos*) and Northern pintails (*A. acuta*) in behaviors during early and late seasons on wetlands open and closed to hunting during the Light Goose Conservation Order in the Rainwater Basin of Nebraska in 2011. Behaviors with differing letters are statistically different ($\alpha < 0.05$); overall behavior did not differ during late season ($P > 0.05$). We classified early season as those weeks prior to the date when greater than 95% of all light geese observed on study wetlands each year had left the RWB region, late season was considered all weeks after that date. All surveys conducted prior to 14 March 2011 were classified as early season.

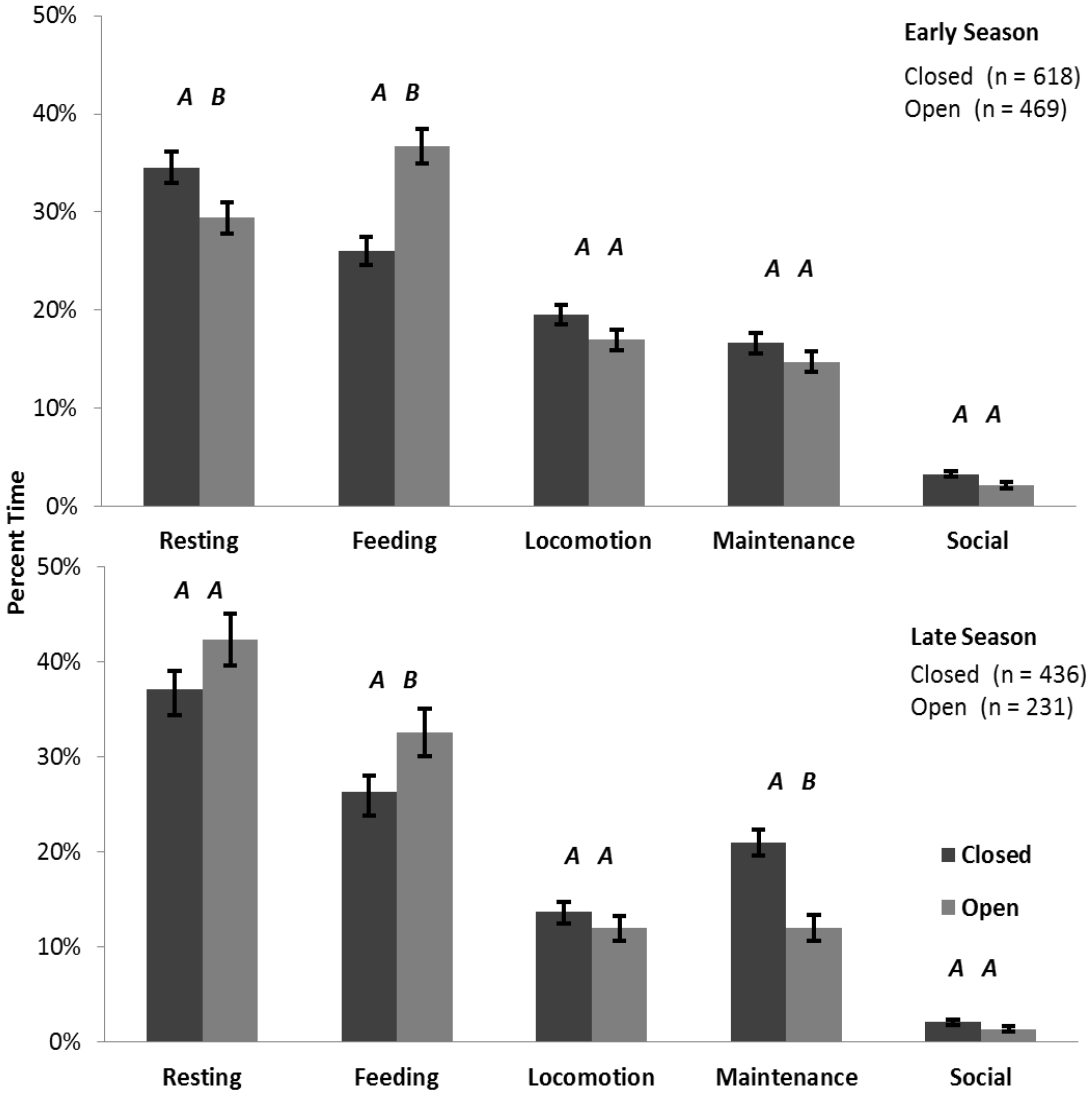

Figure 3.4. Percent time ($\bar{x} \pm$ SE) spent by mallards (*Anas platyrhynchos*) and Northern pintails (*A. acuta*) in behaviors during early and late seasons on wetlands open and closed to hunting during the Light Goose Conservation Order in the Rainwater Basin of Nebraska in 2012. Behaviors with differing letters are statistically different ($\alpha < 0.05$). We classified early season as those weeks prior to the date when greater than 95% of all light geese observed on study wetlands each year had left the RWB region, late season was considered all weeks after that date. All surveys conducted prior to 12 March 2012 were classified as early season.

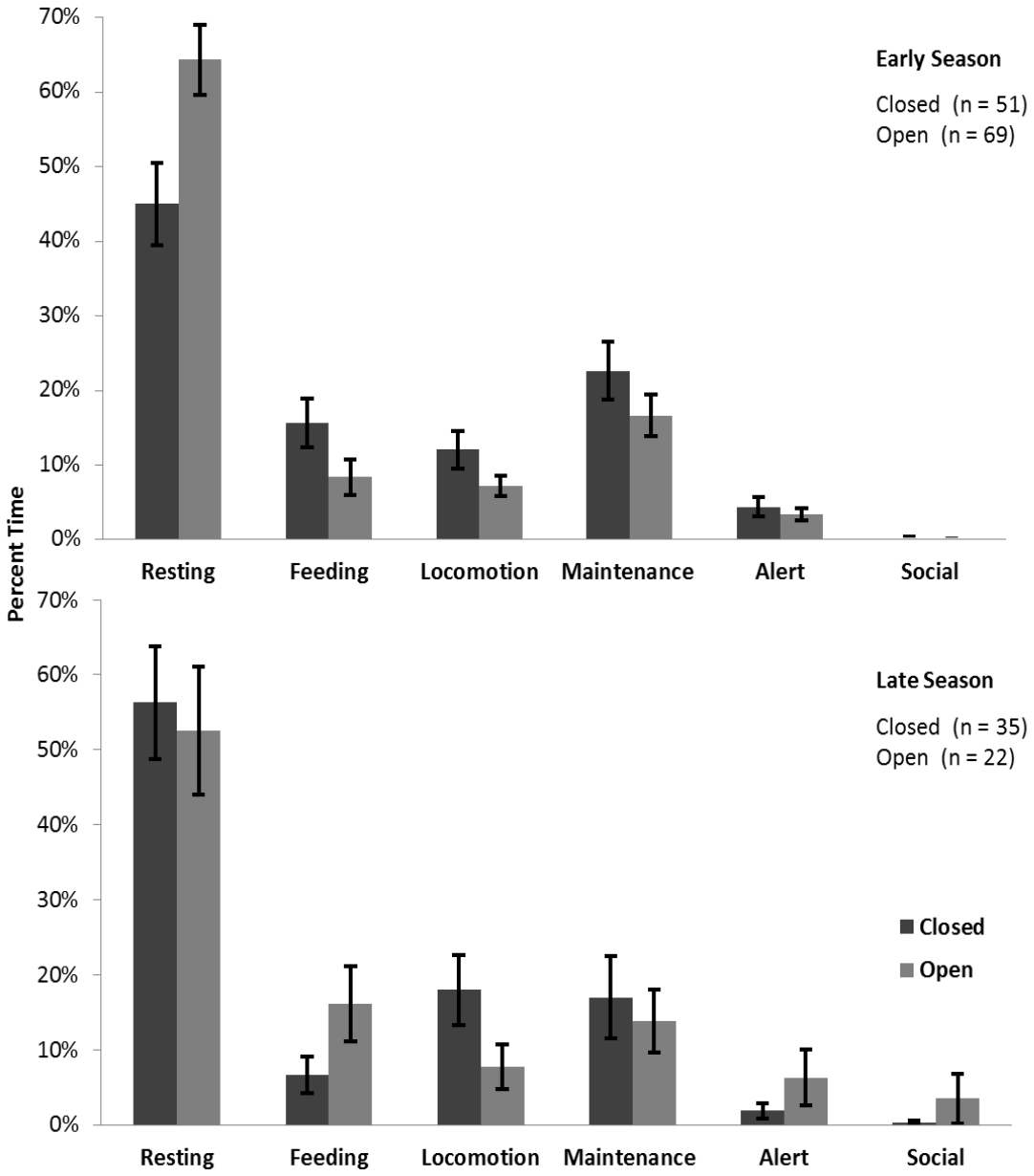

Figure 3.5. Percent time ($\overline{x} \pm$ SE) spent by greater white-fronted geese (*Anser albifrons*) in behaviors during early and late seasons on wetlands open and closed to hunting during the Light Goose Conservation Order in the Rainwater Basin of Nebraska in 2011 and 2012. Overall behaviors did not differ during early or late season (both $P > 0.05$). We classified early season as those weeks prior to the date when greater than 95% of all light geese observed on study wetlands each year had left the RWB region, late season was considered all weeks after that date. All surveys conducted prior to 14 March 2011 and 12 March 2012 were classified as early season.

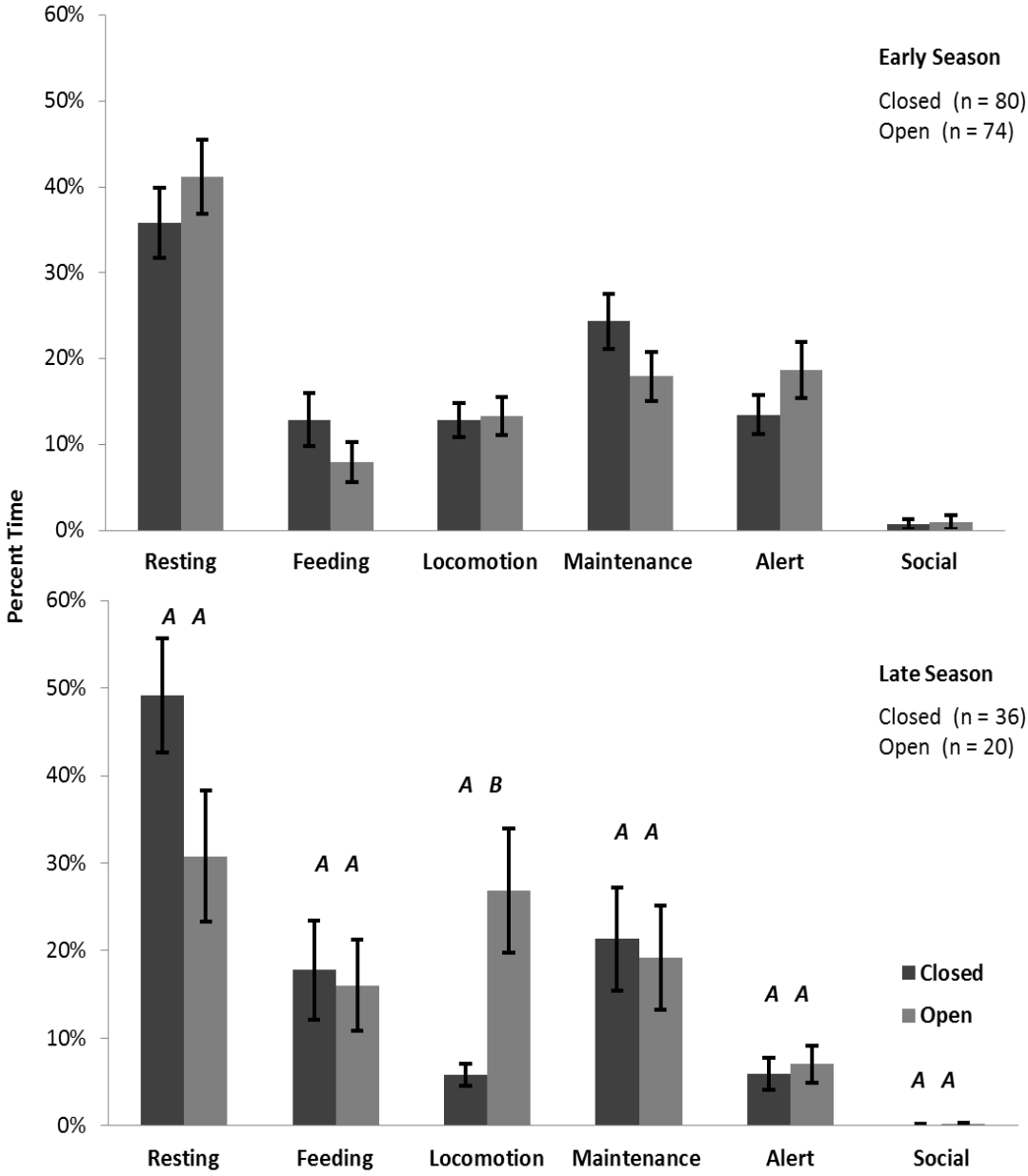

Figure 3.6. Percent time ($\overline{x} \pm$ SE) spent by lesser snow geese (*Chen caerulescens*) in behaviors during early and late seasons on wetlands open and closed to hunting during the Light Goose Conservation Order in the Rainwater Basin of Nebraska in 2011 and 2012. Behaviors with differing letters are statistically different ($\alpha < 0.05$); overall behavior did not differ during early season ($P > 0.05$). We classified early season as those weeks prior to the date when greater than 95% of all light geese observed on study wetlands each year had left the RWB region, late season was considered all weeks after that date. All surveys conducted prior to 14 March 2011 and 12 March 2012 were classified as early season.

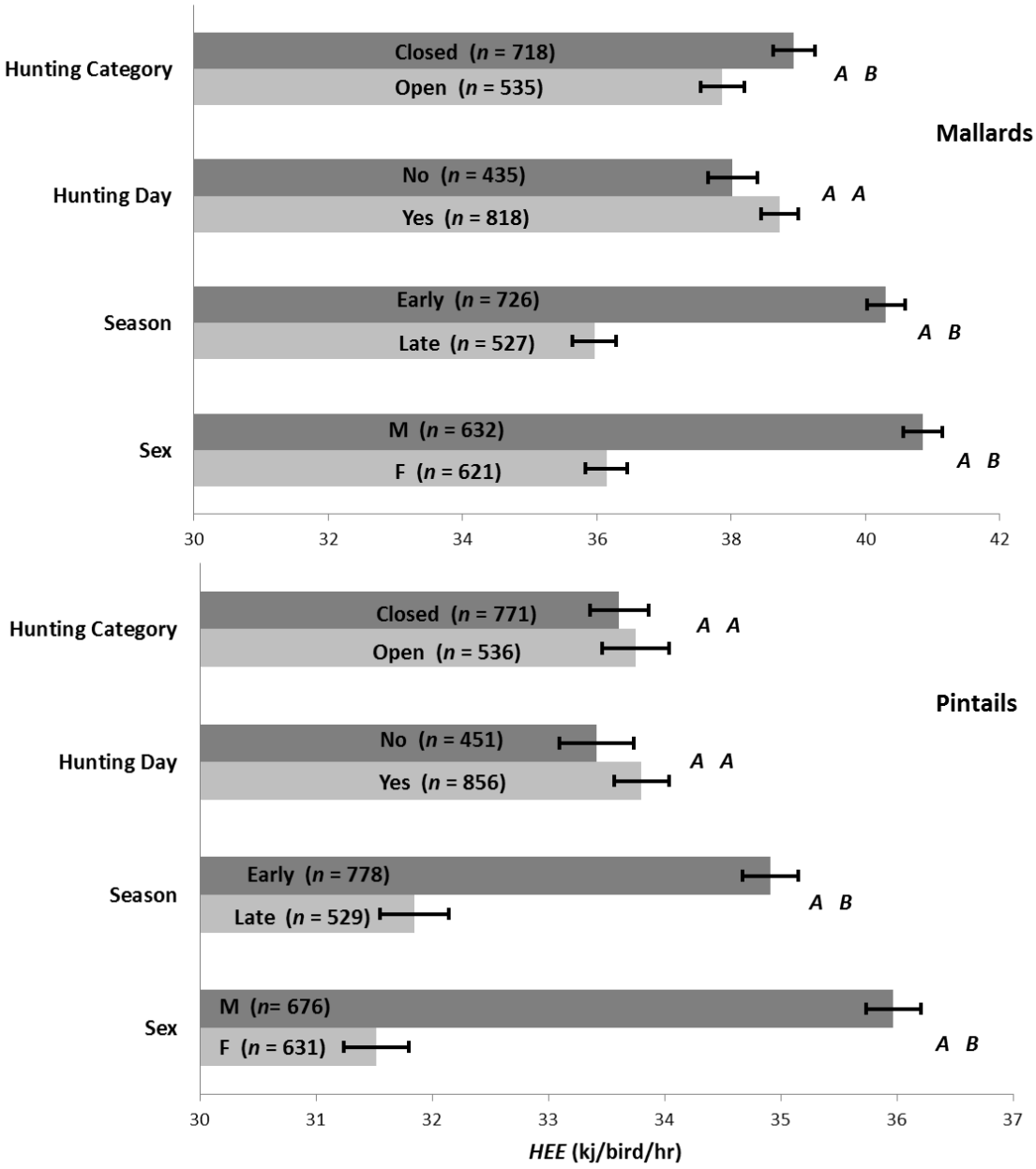

Figure 3.7. Mean (± SE) hourly energy expenditure (kj/bird/hour) of mallards (*Anas platyrhynchos*) and Northern pintails (*A. acuta*) for independent variables of hunting category, hunting day, season, and sex on study wetlands during the Light Goose Conservation Order in the Rainwater Basin of Nebraska in spring 2011 and 2012. Categories with differing letters are statistically different ($\alpha < 0.05$). We classified early season as those weeks prior to the date when greater than 95% of all light geese observed on study wetlands each year had left the RWB region, late season was considered all weeks after that date. All surveys conducted prior to 14 March 2011 and 12 March 2012 were classified as early season.

CHAPTER IV

MIGRATORY BIRD HUNTER OPINIONS REGARDING LIGHT GOOSE CONSERVATION ORDER REGULATIONS AND FUTURE MANAGEMENT STRATEGIES FOR CONTROLLING LIGHT GOOSE POPULATIONS

INTRODUCTION

Interest in human dimensions of wildlife management gained prominence in the early to mid-1980s and has increasingly become an integral component of wildlife management (Manfredo 1989). Human dimension research often focuses on hunter satisfaction and many managing agencies now incorporate hunter satisfaction into management strategies. Harvest regulations can affect hunter satisfaction and short-term hunting participation, but may not reflect the complex relationships among harvest regulations, satisfaction, and participation (Johnson and Case 2000, Case 2004). Although hunter satisfaction may only partially explain hunting participation decisions (Case 2004), providing quality hunting opportunities is a primary goal for wildlife management agencies (Schroeder et al. 2006). Hunter satisfaction provides evaluative feedback to managers, and wildlife agencies may gain public support by emphasizing stakeholder opinions, particularly satisfaction (Riley et al. 2003).

One of the main factors influencing hunting participation is abundance and availability of game (Smith et al. 1992, Frey et al. 2003). According to data from the National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, total numbers of hunters ($\geq$ 16 years of age) increased 46% nationally from 1955 to 1975 (from

approximately 11.7 million to 17.1 million), but by 2005 had decreased 26% to approximately 12.5 million hunters (U.S. Department of the Interior [DOI] 1997, DOI 2012). However, during the same time period number of big-game hunters increased from 4.4 million in 1955 to 10.7 million in 2005, and was likely the result of drastic increases in whitetail deer and turkey populations in the contiguous United States (DOI 1997, DOI 2012). Numbers of migratory bird hunters can be more difficult to identify since participation is often sporadic (Enck et al. 1993) and numbers of breeding ducks (availability of game) counted in the traditional survey area during the Waterfowl Breeding Population and Habitat Survey can vary drastically from year to year depending on water conditions (U.S. Fish and Wildlife Service [USFWS] 2011). However, most data indicate declining trends in the number of waterfowl hunters over the last 20 years (DOI 1997, DOI 2012). From 1990 to 2010 numbers of migratory bird hunters decreased by an estimated 14% (from approximately 3 million to 2.6 million; DOI 1997, DOI 2012), despite an increase in total breeding ducks estimated in the traditional survey area from near record lows in the early 90s to near record highs in 2010 (USFWS 2011).

Increases in mid-continent populations of light geese (lesser snow geese [*Chen caerulescens*] and Ross's geese [*C. rossi*]) resulted in destruction of some arctic breeding habitats (Abraham and Jefferies 1997). Intense grazing of shoots and grubbing of roots and rhizomes by light geese, coupled with a short arctic growing season, led to irreversible loss of vegetation, increased soil salinity, erosion, and desertification in some areas (Srivastava and Jefferies 1996, Abraham and Jefferies 1997, Jefferies and Rockwell 2002). Reduction of mid-continent light goose populations has been a priority in the Central and Mississippi Flyways since the mid-1990s, and in 1999 the USFWS

implemented the Light Goose Conservation Order (LGCO) (Abraham et al. 2005, USFWS 2007). The LGCO allows the legal harvest of light geese after March 10th with the authorized use of electronic calls, unplugged shotguns, removed bag limits, and extended shooting hours for light geese (USFWS 2007). The overall management goal of the LGCO was to reduce mid-continent light goose populations by 50% from levels observed in the late 1990s (USFWS 2007). However, in order for the LGCO to be successful, participation, and subsequent harvest, during this special season must be great enough to effectively control light goose populations.

The LGCO was implemented with caution in the Rainwater Basin of Nebraska (RWB) due to concern from biologists that hunting disturbance might impact the distribution and behavior of non-target waterfowl species in an important spring staging area (Vrtiska and Sullivan 2009). Current LGCO regulations in the RWB limit hunting to four days a week (Saturday, Sunday, Wednesday, and Thursday), and 16 public wetlands are entirely closed to hunting. After the third week of March hunting is allowed seven days a week and the LGCO season closes in the RWB during the second week of April. Although data are collected to quantify annual estimates of light goose harvest and hunter participation during the LGCO in the RWB (Vrtiska 2012), participant satisfaction regarding special regulations is relatively unknown. Increasing hunter satisfaction during the LGCO in the RWB will likely increase participation and ultimately aid in the reduction of mid-continent light goose populations.

Recent evidence suggests mid-continent light goose population growth rates have decreased since the initiation of the LGCO; however, the population has continued to increase, albeit at a slower rate (Alisauskas et al. 2011). Despite the continuous growth

of mid-continent light goose populations (Alisauskas et al. 2011, Alisauskas et al. 2012), number of hunters participating in the LGCO in the Central and Mississippi Flyways have also declined by 53% since 2000 (USFWS 2012). In addition, previous population analyses likely underestimated the number of light geese, which may have resulted in overconfidence in the ability of the LGCO to reduce light goose populations, and current participation levels during the LGCO may not be great enough to control light goose populations (Alisauskas et al. 2011). To effectively control light goose populations, additional active management including direct control methods such as trapping flightless geese on breeding grounds or euthanizing light geese on wintering areas using bait with approved chemicals may be necessary (Johnson and Ankney 2003). Although some direct control measures are considered highly controversial (Leafloor et al. 2012), hunter and general public perception, opinions, and support regarding wildlife officials directly controlling light goose populations are relatively unknown.

We expanded the Nebraska LGCO harvest survey in spring 2012 to assess migratory bird hunter opinions of current LGCO regulations and future management strategies for controlling light goose populations. The objectives for this chapter were to quantify hunter opinions and support for current and hypothetical changes to regulations during the LGCO in the RWB and evaluate hunter opinions regarding future management strategies and methods for controlling light goose populations. We also evaluated differences in responses of Nebraska residents and non-residents for some survey items. Non-resident hunters may provide an influx of money to state and local economies (Grado et al. 2001, Wallace et al. 2005), and may tend to hunt longer and potentially have a higher daily success rate, presumably because of their greater expenditure in time and

money for travel (Sen 1984). As a result, managers may use differences in responses between resident and non-resident to better manage for both types of hunters. We also assessed differences between participants (those who participated in the LGCO during 2012) and non-participants for some survey items. Responses of current participants may help agency biologists increase satisfaction among current LGCO participants and non-participant responses may provide insight into factors influencing others to not participate during the LGCO. We also speculated that current participants would be less supportive of wildlife officials using any form of direct control methods for light geese and tested differences between participation groups for all questions dealing with potential future management strategies. Information obtained in the survey could potentially be used to incorporate hunter opinions and satisfaction into future LGCO regulations in the RWB and provide wildlife managers future direction regarding management strategies to control light goose populations.

METHODS

Selection of Hunters and Survey Design

Mail survey sampling was stratified for purposes of estimating participation and harvest during the LGCO by the Nebraska Game and Parks Commission (NGPC). We used this sampling protocol to add additional survey questions to the annual harvest survey sent to hunters by the NGPC. Cyberdata (Hicksville, New York) provided both Internet and telephone support for the Harvest Information Program (HIP) registration of Nebraska's migratory bird hunters (Vrtiska 2012). We deleted duplicate addresses and names in the HIP database and limited mailing surveys to one per household. We then

divided the list of HIP registrants into those who registered prior to, and those registering after the start of the LGCO (6 February 2012). Participants registering after the start of 2012 LGCO were designated as the SPRING group, as we assumed they did not participate in regular season waterfowl hunting. We further stratified those registering prior to the start of the LGCO into three groups (SNOW, DUCK and OTHER) based on assumed different levels of participation in the LGCO. The SNOW group was comprised of individuals who indicated on the HIP survey that they had hunted light geese the previous spring (February-April 2011). Individuals in the DUCK group were those who had hunted waterfowl (excluding 2011 LGCO) in fall 2011 and the OTHER group was comprised of individuals who indicated they had hunted other migratory birds in fall 2011.

The survey questionnaire and cover letter consisted of four pages printed on ledger sized paper and folded into pamphlet form prior to mailing (Appendix 1 and 2). The survey contained questions regarding hunting participation and regulations (survey items 1-14) and hypothetical regulations that could potentially be used in the RWB in the future (survey items 15-20) (Appendix 2). Other survey questions were related to future light goose management strategies (survey items 21-28) and alternatives for light goose control which could potentially be implemented by wildlife officials (survey items 29-33) (Appendix 2). A five-point Likert scale was used along with a no opinion option to gauge hunter opinion/support for each survey item (White et al. 2005). Response categories ranged from 1 (completely disagree) to 5 (completely agree) or from 1 (completely unsupportive) to 5 (completely supportive). Respondents were also asked to indicate their state residency and participation (Appendix 2). We considered respondents

participants if they indicated they hunted light geese in Nebraska during spring 2012, and non-participants if they indicated they did not hunt light geese. We also determined total light geese harvested by each participant in Nebraska during 2012 based on the initial harvest question (Appendix 2). Survey cover letter ensured informed consent and confidentiality of responses. The University of Missouri Institutional Review Board (IRB) approved the sampling frame, survey document, and survey protocols (Project Number 1201350).

A mass mailing of surveys was made one day after closure of the LGCO in Nebraska (15 April 2012). We mailed a survey questionnaire to all persons in the SPRING group (n = 828) who registered after the start of the LGCO in 2012. We then randomly selected names from the HIP database for the remaining stratified groups and attempted to mail surveys to approximately 1,000 participants each from the SNOW and DUCK groups and 1,500 participants from the OTHER group. We mailed a total of 4,151 surveys, along with prepaid return envelopes. We also sent a reminder postcard 10 days after the mailing of the 4-page survey following a modified Dillman protocol (Dillman 1991) (Appendix 3). The number of surveys returned declined sharply by the end of May and no surveys received after 1 June 2012 were incorporated into our database.

Statistical Analyses

We calculated frequencies (%) of response categories and overall mean scores (based on a 1-5 Likert scale) to gauge support for each survey item (PROC FREQ, PROC MEANS; SAS Institute Inc. 2010). We excluded responses of 'no opinion' from statistical analyses except when calculating frequencies of responses. We were

particularly interested if responses to the first six questions relating to hunting participation as well as the set of potential regulations that could be implemented in the RWB differed between residents and non-residents and also if responses for these survey items differed between participants and non-participants. To compare responses between residency and participation categories for each survey item we again used a Kruskal-Wallis nonparametric 1-way ANOVA and designated $\alpha < 0.05$ with a Bonferroni adjustment for 12 individual tests (PROC NPAR1WAY; SAS Institute Inc. 2010). We also determined differences in responses between participants and non-participants for survey items pertaining to future light goose management strategies and alternatives for light goose control. Similarly, we tested for response differences in the same survey items between participants who harvested < 10 light geese and participants who harvested ≥ 10 light geese to assess if hunters who harvested more light geese had stronger opinions regarding future light goose management strategies. We tested differences in responses among harvest groups for each survey item with a Kruskal-Wallis test and designated $\alpha < 0.05$ with a Bonferroni adjustment for 13 separate tests. To check for non-response bias we assumed that the later a participant responded to the mail survey, the more they took on characteristics of a non-respondent (Brunke and Hunt 2008). We used a Kruskal-Wallis nonparametric 1-way analysis of variance (ANOVA) to compare early responders ($n = 280$), which included all surveys received within 10 days after the mailing of the survey (15 April-24 April 2012) with late responders ($n = 75$) for each survey item (PROC NPAR1WAY; SAS Institute Inc. 2010). Late responders included all surveys received during the last two weeks of survey collection (13 May-30 May 2012). We used a significance level of $\alpha < 0.05$ with a Bonferroni adjustment for 33 individual tests to

determine non-response bias. All statistical analyses were performed with SAS software version 9.3 (SAS Institute Inc. 2010). All response values are reported as means (five-point Likert scale) ± standard error. A complete listing of means and frequency of responses for all survey items are reported in Appendix 2.

RESULTS

Six surveys were returned undeliverable, for an effective mailing of 4,145 surveys. A total of 977 surveys were returned, yielding an overall response rate of 24%. Among returned surveys, 189 of the respondents indicated they did not hunt light geese in 2012 and answered no further questions; these surveys were excluded from statistical analyses. Of the surveys used for statistical analyses, 69% (n = 547) of respondents were Nebraska residents, while 31% (n = 241) were from other states. People who participated in the 2012 LGCO made up of 43% (n = 338) of respondents, while 57% (n = 450) of respondents did not participate in the LGCO during 2012. Individuals who indicated harvest of < 10 light geese comprised 57% (n = 191) of participants, while 43% (n = 147) of participants harvested ≥ 10 light geese. We detected no differences between early and late responders for any survey items (all $\chi^2 \leq 4.18$, $P \geq 0.041$). Given similarities in responses between early and later responders to all survey items, we concluded non-response bias was relatively low.

Hunter Opinions Regarding Regulations

The majority of hunters surveyed agreed that it was important to have special regulations to minimize disturbance to other waterfowl species during the LGCO in the RWB ($\overline{x}$ = 3.65 ± 0.05) and we detected no response differences between residency or

participation categories (Tables 4.1 and 4.3). Hunters also generally agreed that they were satisfied with current LGCO regulations in the RWB ($\overline{x}$ = 3.20 ± 0.05) with no response differences between residency or participation categories (Tables 4.1 and 4.3). However, hunters agreed that they would participate more frequently if existing LGCO regulations in the RWB were simplified ($\overline{x}$ = 3.44 ± 0.05) and less frequently if existing regulations became more complex ($\overline{x}$ = 3.32 ± 0.06) and we detected no differences in responses among residency or participation groups for either survey item (Tables 4.1 and 4.3). Residents ($\overline{x}$ = 3.50 ± 0.07) and non-participants ($\overline{x}$ = 3.56 ± 0.08) were more likely to agree that they currently participate fewer days during the LGCO in the RWB than in previous years, compared to non-residents ($\overline{x}$ = 2.87 ± 0.11) and participants ($\overline{x}$ = 3.10 ± 0.08) (Tables 4.1 and 4.3). Residents ($\overline{x}$ = 2.93 ± 0.07) and non-participants ($\overline{x}$ = 3.07 ± 0.09) also agreed more that they primarily hunt public land while participating in the LGCO in the RWB, compared to non-residents ($\overline{x}$ = 2.28 ± 0.11) or participants ($\overline{x}$ = 2.43 ± 0.09) (Tables 4.1 and 4.3).

Hunters also agreed that costs associated with spring light goose hunting (gas, decoys, ammunition etc.) made them less likely to participate ($\overline{x}$ = 3.41 ± 0.05). Although hunters generally agreed they were satisfied with current regulations, when presented with regulatory alternatives, they were most supportive of a LGCO season that included sites open to hunting all day, seven days a week, but with more publicly owned wetlands closed to hunting ($\overline{x}$ = 3.06 ± 0.06). Current LGCO regulations (season open four days a week [Tues/Wed, Sat/Sun] and open all day with 16 public wetlands closed) were the second most supported regulatory alternative in the RWB ($\overline{x}$ = 2.98 ± 0.06). Support for either regulatory alternative did not differ between residency (Table 4.2), or

participation categories (Table 4.4). Hunters were least supportive of all alternative regulations in which hunting would be closed after 1 p.m. on days open to hunting. Non-residents strongly agreed they would increase participation during the LGCO in the RWB if a license was available for the entire LGCO that was less expensive than the annual non-resident hunting license ($\overline{x}$ = 3.88 ± 0.10).

Hunter Opinions Regarding Control of Light Goose Populations

Hunters strongly agreed that population control of light geese was an important wildlife management and conservation issue ($\overline{x}$ = 4.64 ± 0.03) and we detected no response differences between participants and non-participants (Table 4.5). Hunters were somewhat neutral in their opinions on how effective the LGCO had been at controlling light goose populations ($\overline{x}$ = 3.12 ± 0.04) and responses did not differ between participation categories (Table 4.5). Participants more strongly agreed that liberalization of hunting regulations during the LGCO, such as unplugged shotguns and electronic calls, increased their harvest of light geese ($\overline{x}$ = 4.31 ± 0.05), compared to non-participants ($\overline{x}$ = 3.84 ± 0.06) (Figure 4.5). Hunters were fairly neutral ($\overline{x}$ = 3.03 ± 0.05) when asked if their participation would increase if techniques such as live decoys or baiting were allowed during the LGCO, with no differences between participation categories (Table 4.5). Participants more strongly disagreed that they limited their take of light geese due to the taste of the meat ($\overline{x}$ = 2.07 ± 0.07), compared to non-participants ($\overline{x}$ = 2.82 ± 0.08) (Table 4.5). Hunters generally did not support legalization for commercial trade of light geese ($\overline{x}$ = 2.73 ± 0.06) and responses did not differ between participants or non-participants (Table 4.5). Hunters also agreed that processing light geese directly harvested by wildlife officials for human consumption or other uses was

important to them ($\overline{x}$ = 3.29 ± 0.05) and no differences were detected between participation categories (Table 4.5).

Non-participants were generally more supportive of wildlife officials using alternative methods to control light goose populations ($\overline{x}$ = 3.29 ± 0.07), compared to participants ($\overline{x}$ = 2.69 ± 0.08) (Table 4.5). When presented with alternative methods for use by wildlife officials for future control of light goose populations, hunters were most supportive of wildlife agencies selectively shooting light geese on migration and wintering areas ($\overline{x}$ = 3.40 ± 0.05) and least supportive of wildlife officials using bait with approved chemicals to euthanize light geese on migration and wintering areas ($\overline{x}$ = 1.84 ± 0.04). In general, participants were less supportive than non-participants for all methods of direct control (Table 4.6). We detected a response difference between responses of participants who harvested < 10 light geese and participants who harvested ≥ 10 light geese for only one survey item (item 23). Participants who harvested ≥ 10 light geese agreed more strongly that liberalized LGCO regulations, such as unplugged shotguns, increased their harvest ($\overline{x}$ = 4.57 ± 0.07), compared to participants who harvested < 10 light geese ($\overline{x}$ = 4.10 ± 0.08) (χ^2 = 23.44, P < 0.001).

DISCUSSION

Hunter Opinions Regarding Regulations

Wildlife professionals need to explicitly state the purpose of various hunting regulations to provide hunters with a basic understanding of the biological reasoning behind regulations (Nichols et al. 1995). The majority of hunters in our survey expressed satisfaction with current regulations and agreed that special regulations, which limit

hunting time and establish refuges, during the LGCO in the RWB, were important to minimize disturbance to non-target waterfowl species. Our findings indicate that hunters have been well educated or have some understanding as to why special regulations were established and it is unlikely further efforts by NGPC and USFWS officials are necessary to educate hunters on the purpose of LGCO special regulations. However, continuous education and effective communications between wildlife managers and migratory bird hunters can only improve mutual understanding of special regulations during the LGCO in the RWB (Woolf and Roseberry 1998).

In response to demands for increased hunting opportunities in North America, waterfowl harvest regulations have expanded to include features such as special seasons on more abundant species, geographic zoning, and species-specific bag limits (USFWS 1988 and 2010). These regulations, along with basic season lengths and bag limits, create an often confusing network of regulatory options for migratory bird hunters (Williams and Johnson 1995). Complexity of hunting regulations can also greatly contribute to uncertainty regarding population responses to management effects and it is often unclear whether it increases hunter satisfaction (Nichols et al. 1995). Our survey results suggest hunters would prefer simple LGCO regulations and that the majority of hunters would participate less if existing regulations became more complex. Waterfowl hunters in New York who have disassociated from waterfowl hunting identified confusing regulations regarding huntable duck species as the most frequent reason for temporary or permanent disassociation (Enck et al. 1993). Maintaining simplified LGCO regulations in the RWB may help retain hunters, encourage hunters to participate more frequently, and perhaps facilitate recruitment of future participants.

Currently non-resident hunters who wish to participate in the LGCO in Nebraska need to have an annual non-resident small game permit, habitat stamp, state waterfowl stamp, and federal migratory bird stamp, which in 2012 cost non-resident hunters a total of $121 (Vrtiska 2012). Our results indicate non-resident participation may increase if a permit were available for non-residents which allowed them to hunt in Nebraska only during the LGCO for a reduced price. Missouri allows non-resident hunters to participate in the LGCO through possession of only a LGCO permit which costs $40, with no requirement for small game permits, state, or federal stamps (Raedeke 2012). Missouri also allows residents to hunt during the LGCO with the purchase of a $6 permit, and does not require any additional stamps or licenses (Raedeke 2012). Providing a LGCO specific permit in Nebraska for residents and non-residents, regardless of cost, would also eliminate stratification of the Nebraska LGCO annual harvest survey and provide better estimates of participation and harvest during the LGCO season.

The regulatory option most supported by hunters in our survey included a season open to hunting seven days a week with additional public wetlands closed to hunting. The second most supported regulations were those currently implemented, which allowed hunting only four days a week, indicating there is likely a trade-off for some hunters who would prefer less hunting time if more public wetlands were open to hunting. Current participants were less supportive than non-participants for any regulatory package which closed hunting at 1 p.m., suggesting current participants were not satisfied with the amount of hunting time these regulatory alternatives would provide. The amount of leisure time people have to participate in hunting activities has been identified by several studies as a potential impediment to hunting participation (Enck et al. 1993, Duda et al.

1995, Shulz et al. 2003). A seven day season might allow hunters to more easily fit participation into their schedules, as well as allow hunters traveling long distances to extend weekend hunting trips into weekdays. The majority of hunters who participated during the 2012 LGCO also disagreed that they primarily hunt public land in the RWB. A seven day season may lead to increased participation on private lands, which may limit further disturbance to non-target waterfowl species on public wetlands managed primarily for spring migrating waterfowl. Hunters may also perceive a season open seven days a week as a step towards simplifying regulations. Hunters would be able to hunt any day of the week and there would be no change in allowable hunting days during the third week of March. Current regulations allowing hunting four days a week have also been seen as an impediment for guiding services to use the RWB for their services (M. Vrtiska, NGPC, personal communication). A season open seven days a week may bring more guiding services into the area, which has the potential to lead to conflicts or concerns from local hunters (Eliason 2012). If LGCO regulations are changed in the RWB, we suggest an adaptive management approach (Johnson and Williams 1999, Enck et al. 2006) with continuous evaluation of regulatory changes and their effects on waterfowl distribution, as well as hunter participation and satisfaction.

Hunter Opinions Regarding Control of Light Goose Populations

Despite implementation of the LGCO in the late 1990s that allowed for unprecedented light goose harvest regulations (Batt 1997, USFWS 2007), continental populations of light geese continue to increase (Alisauskas et al. 2011 and Alisauskas 2012). In fact, Alisauskas et al. (2011) expressed confidence that the current abundance and population growth rate of light goose populations exceeds the ability of existing

hunters to effectively influence population growth. The vast majority of hunters in our survey agreed that population control of light geese is an important wildlife management and conservation issue. However, most hunters were neutral in their opinions on whether or not the LGCO has been effective at controlling light goose populations. Our results suggest initial efforts by wildlife managers to inform hunters about the problems caused by over-abundance of certain arctic and sub-arctic goose populations were successful (Batt 1997). However, new education efforts informing hunters and general public about current status of light goose populations, arctic habitat conditions, and effectiveness of the LGCO are likely needed.

We found fairly neutral support from migratory bird hunters as a group for wildlife officials using alternative methods beyond current measures to control light goose populations. Hunters participating during the "snow goose only season" prior to the LGCO in Louisiana, Arkansas, and Iowa were also least supportive of agency capture/kill compared with any other proposed management actions (Olsen and Afton 1999). In another study, residents in central Missouri were generally unsupportive of lethal control methods for Canada geese, however in situations where geese were causing serious damage and special hunts and landowner kill permits were the only means of control, 71% of residents indicated approval of lethal control measures and an additional 13% indicated approval with the further stipulations that geese were killed in a humane manner and the meat was processed for human consumption (Coluccy et al. 2001). Gaining public support will be essential for wildlife managers to move forward with any additional control actions. Education through publications and various media outlets will be imperative, and should focus on informing hunters and the general public that light

goose populations continue to increase (Alisauskas et al. 2011 and Alisauskas 2012), continue to destroy arctic habitats with little evidence of recovery (Abraham et al. 2012), and that agencies have exhausted all means within the realm of sport hunting in an effort to control light goose populations.

Hunters who participated in the 2012 LGCO were less supportive than non-participants in our survey for alternatives that wildlife officials could potentially use for directly controlling light goose populations. Future education efforts may consider ensuring LGCO participants are well informed there will likely be no changes to current LGCO provisions if any direct control actions are taken by wildlife agencies, unless regulations become less restrictive if deemed acceptable by society. Also, given relatively high growth rates of various light goose populations, very liberal harvest would still likely be necessary to maintain populations at manageable levels even after any population control actions are successfully implemented (Leafloor et al. 2012). Consideration should also be given to regulatory changes or other incentives that promote participation in light goose hunting, and offer hunters additional flexibility for transport, possession, gifting, and perhaps commercial sale of legally harvested birds (Johnson and Ankney 2003). Education of hunters for the purpose of developing understanding of and commitment to their role in management may be essential to the eventual success of light goose management (Decker and Connelly 1990).

Various harvest provisions implemented to date during the LGCO should not be viewed as a short-term solution, but rather, as a central part of a stabilized regulatory framework, to which additional population reduction efforts could be applied (Alisauskas et al. 2011). In order for light goose population reduction to be successful, it will likely

take efforts from not only hunters, but wildlife agencies using perhaps several different methods of direct control (Johnson and Ankney 2003, Leafloor et al. 2012). While various direct control strategies have potential to help reduce light goose populations, each strategy likely comes with unique moral and ethical concerns, making certain direct control alternatives more contentious than others (Johnson and Ankney 2003). For example, we found hunters were least likely to express support for wildlife officials euthanizing light geese on migration and wintering areas using bait with approved chemicals. Cost-effectiveness of certain direct control strategies also needs further evaluation. Among direct control alternatives, hunters were most supportive of wildlife officials selectively shooting light geese on migration and winter areas, however, it is unknown if this is the most cost-effective method wildlife officials could use for controlling light goose populations or how information on public costs of different control measures may influence public support for the various options. We suggest a more in-depth survey approach, which covers states in flyways with overabundant light goose populations, that gauges not only hunter support, but support of the general public regarding options for directly controlling light geese. An evaluation of cost and feasibility of direct control techniques is also needed; although some work has already been done (Johnson and Ankney 2003), a more thorough investigation is likely needed for some direct control options. A clear understanding of public perception and cost-effectiveness of the various potential direct control options are necessary for wildlife biologists to make informed decisions on how to proceed with population control of light geese.

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Table 4.1. Mean (± SE) response scores of state resident (n = 547) and non-resident (n = 241) Nebraska migratory bird hunters for survey items pertaining to hunting participation and regulations during the Light Goose Conservation Order in the Rainwater Basin of Nebraska. Mean scores based on a 5-point Likert scale where 1 = "completely disagree" and 5 = "completely agree."

Survey Item	**Resident**	**Non-Resident**	χ^2	***P-value*[1]**
It is important that special regulations are in place to minimize disturbance to other waterfowl species during the LGCO in the RWB.	3.7 ± 0.06	3.6 ± 0.10	0.26	0.607
I would participate more frequently during the LGCO in the RWB if existing regulations were simplified.	3.5 ± 0.06	3.4 ± 0.10	0.31	0.575
I participate fewer days now during the LGCO in the RWB than I have in previous years.	3.5 ± 0.07	2.9 ± 0.11	21.77	< 0.001*
I would participate less frequently during the LGCO in the RWB if existing regulations were more complex.	3.3 ± 0.07	3.4 ± 0.10	1.16	0.281
I am satisfied with current regulations (four days open to hunting and 16 public wetlands closed entirely) during the LGCO in the RWB.	3.2 ± 0.06	3.2 ± 0.10	0.08	0.777
I primarily hunt public land while participating in the LGCO in the RWB.	2.9 ± 0.07	2.3 ± 0.10	22.81	< 0.001*

[1]*denotes differences between groups at ($\alpha < 0.05$) with a Bonferroni adjustment for 12 individual tests

Table 4.2. Mean (± SE) response scores of state resident (n = 547) and non-resident (n = 241) Nebraska migratory bird hunters for survey items pertaining to current and potential future regulations during the Light Goose Conservation Order in the Rainwater Basin of Nebraska. Mean scores based on a 5-point Likert scale where 1 = "completely unsupportive" and 5 = "completely supportive."

Survey Item	**Resident**	**Non-Resident**	χ^2	***P-value*[1]**
Open 4 days (Tues/Wed, Sat/Sun) open all day (current regulations).	3.1 ± 0.07	2.8 ± 0.11	5.46	0.019
Open 7 days, open all day, but more public basins closed to hunting than current regulations.	3.0 ± 0.07	3.2 ± 0.11	3.72	0.054
Open 5 days (Tues-Thurs, Sat/Sun), open all day, but a few more public basins closed to hunting than current regulations.	2.7 ± 0.06	2.6 ± 0.10	0.18	0.673
Open 7 days, closed after 1 p.m., but more public basins closed to hunting than current regulations.	2.3 ± 0.06	2.3 ± 0.09	0.32	0.569
Open 5 days (Tues-Thurs, Sat/Sun), closed after 1 p.m., but a few more public basins closed to hunting than current regulations.	2.3 ± 0.06	2.1 ± 0.09	3.74	0.0531
Open 4 days (Tues/Wed, Sat/Sun) closed after 1 p.m.	2.1 ± 0.05	2.0 ± 0.09	3.05	0.0809

[1]*denotes differences between groups at ($\alpha < 0.05$) with a Bonferroni adjustment for 12 individual tests

Table 4.3. Mean (± SE) response scores of participant (*n* = 338, indicated they hunted during the Light Goose Conservation Order in 2012) and non-participant (*n* = 450) Nebraska migratory bird hunters for survey items pertaining to hunting participation and regulations during the Light Goose Conservation Order in the Rainwater Basin of Nebraska. Mean scores based on a 5-point Likert scale where 1 = "completely disagree" and 5 = "completely agree."

Survey Item	**Participant**	**Non-Participant**	χ^2	***P-value*[1]**
It is important that special regulations are in place to minimize disturbance to other waterfowl species during the LGCO in the RWB.	3.5 ± 0.07	3.8 ± 0.07	4.12	0.043
I would participate more frequently during the LGCO in the RWB if existing regulations were simplified.	3.4 ± 0.07	3.5 ± 0.07	0.07	0.789
I would participate less frequently during the LGCO in the RWB if existing regulations were more complex.	3.3 ± 0.08	3.3 ± 0.08	0.03	0.852
I am satisfied with current regulations (four days open to hunting and 16 public wetlands closed entirely) during the LGCO in the RWB.	3.2 ± 0.08	3.2 ± 0.07	0.38	0.537
I participate fewer days now during the LGCO in the RWB than I have in previous years.	3.1 ± 0.08	3.6 ± 0.08	16.06	< 0.001*
I primarily hunt public land while participating in the LGCO in the RWB.	2.4 ± 0.09	3.1 ± 0.09	27.26	< 0.001*

[1]*denotes differences between groups at ($\alpha < 0.05$) with a Bonferroni adjustment for 12 individual tests

Table 4.4. Mean (± SE) response scores of participant (*n* = 338, indicated they hunted during the Light Goose Conservation Order in 2012) and non-participant (*n* = 450) Nebraska migratory bird hunters for survey items pertaining to current and potential future regulations during the Light Goose Conservation Order in the Rainwater Basin of Nebraska. Mean scores based on a 5-point Likert scale where 1 = "completely unsupportive" and 5 = "completely supportive."

Survey Item	**Participant**	**Non-Participant**	χ^2	***P-value*[1]**
Open 7 days, open all day, but more public basins closed to hunting than current regulations.	3.1 ± 0.08	3.0 ± 0.08	1.63	0.202
Open 4 days (Tues/Wed, Sat/Sun) open all day (current regulations).	2.9 ± 0.08	3.1 ± 0.08	2.41	0.120
Open 5 days (Tues-Thurs, Sat/Sun), open all day, but a few more public basins closed to hunting than current regulations.	2.7 ± 0.08	2.6 ± 0.07	0.04	0.833
Open 7 days, closed after 1 p.m., but more public basins closed to hunting than current regulations.	2.1 ± 0.07	2.5 ± 0.07	18.49	< 0.001*
Open 5 days (Tues-Thurs, Sat/Sun), closed after 1 p.m., but a few more public basins closed to hunting than current regulations.	2.1 ± 0.06	2.4 ± 0.07	12.91	< 0.001*
Open 4 days (Tues/Wed, Sat/Sun) closed after 1 p.m.	1.9 ± 0.07	2.3 ± 0.07	16.49	< 0.001*

[1]*denotes differences between groups at ($\alpha < 0.05$) with a Bonferroni adjustment for 12 individual tests

Table 4.5. Mean (± SE) response scores of participant (*n* = 338, indicated they hunted during the Light Goose Conservation Order in 2012) and non-participant (*n* = 450) Nebraska migratory bird hunters for survey items pertaining to the future control of light goose populations. Mean scores based on a 5-point Likert scale where 1 = "completely disagree" and 5 = "completely agree."

Survey Item	**Participant**	**Non-Participant**	χ^2	***P-value*[1]**
The population control of light geese is an important wildlife management and conservation issue.	4.7 ± 0.03	4.6 ± 0.04	5.93	0.015
The liberalization of hunting regulations during the LGCO, such as unplugged shotguns, electronic calls, and extended shooting hours increases my harvest of light geese.	4.3 ± 0.05	3.8 ± 0.06	37.60	< 0.001*
Processing light geese that have been directly harvested by wildlife officials for human consumption or other uses is important to me.	3.2 ± 0.08	3.4 ± 0.06	6.21	0.013
Since being enacted in 1999, the LGCO has been effective at controlling light goose populations.	3.2 ± 0.07	3.1 ± 0.06	2.12	0.145
Further liberalization of regulations, such as live decoys or baiting would increase my participation during the LGCO.	3.1 ± 0.08	3.0 ± 0.07	0.39	0.530
I would support wildlife officials using alternative methods other than spring hunting to control light goose populations.	2.7 ± 0.08	3.3 ± 0.07	31.75	< 0.001*
I would support legalizing the commercial trade of harvested light geese.	2.7 ± 0.08	2.8 ± 0.08	2.37	0.123
I am capable of harvesting more light geese during the LGCO, but limit my take due to the taste of light goose meat.	2.1 ± 0.07	2.8 ± 0.08	53.50	< 0.001*

[1]*denotes differences between groups at ($\alpha < 0.05$) with a Bonferroni adjustment for 13 individual tests

Table 4.6. Mean (± SE) response scores of participant (*n* = 338, indicated they hunted during the Light Goose Conservation Order in 2012) and non-participant (*n* = 450) Nebraska migratory bird hunters for survey items pertaining to options for directly controlling light goose populations. Mean scores based on a 5-point Likert scale where 1 = "completely unsupportive" and 5 = "completely supportive."

Survey Item	**Participant**	**Non-Participant**	χ^2	***P-value*[1]**
Selectively shooting light geese on migration and wintering areas.	3.1 ± 0.08	3.7 ± 0.06	29.19	< 0.001*
Selectively shooting light geese on arctic breeding grounds.	2.5 ± 0.07	3.0 ± 0.07	17.71	< 0.001*
Trapping and euthanizing flightless light geese on arctic breeding grounds.	2.4 ± 0.08	2.8 ± 0.07	13.80	< 0.001*
Trapping and euthanizing light geese on migration and wintering areas.	2.1 ± 0.07	2.7 ± 0.07	25.69	< 0.001*
Euthanizing light geese on migration and wintering areas using bait with approved chemicals.	1.7 ± 0.06	2.0 ± 0.06	9.61	0.002*

[1]*denotes differences between groups at ($\alpha < 0.05$) with a Bonferroni adjustment for 13 individual tests

CHAPTER V

SUMMARY

The Rainwater Basin (RWB), located in south-central Nebraska, is recognized as one of the most important regions for migratory waterfowl in North America (U.S Fish and Wildlife Service [USFWS] and Canadian Wildlife Service 1986). Despite conversion of approximately 90% of the original number of wetlands to agriculture lands (Smith and Higgins 1990), the area still serves as a major spring staging area for millions of waterfowl in North America (Gersib et al. 1989, Bishop and Vrtiska 2008). Since the 1970s, mid-continent populations of light geese (lesser snow geese [*Chen caerulescens*] and Ross's geese [*C. rossi*]) have increased substantially, resulting in long term damage to some arctic breeding areas (Batt 1997). In the late 1980s and early 1990s, relatively large numbers of light geese also began staging in the RWB (Vrtiska and Sullivan 2009).

In an effort to reduce light goose populations, the USFWS implemented the Light Goose Conservation Order (LGCO) in 1999, which permitted legal harvest of light geese after March 10th (USFWS 2007). However, there was considerable concern that LGCO activities could potentially negatively impact non-target waterfowl species in the RWB (Vrtiska and Sullivan 2009); specifically that hunting disturbance might limit nutrient acquisition during spring migration (Arzel et al. 2006). As a result, LGCO regulations were implemented with caution in the RWB. Current regulations allow hunting four days a week (Saturday, Sunday, Wednesday, and Thursday), and a total of 16 public wetlands are closed to hunting during the LGCO. Although regulations were established with a goal of maximizing light goose harvest, while minimizing impacts to non-target species

(Vrtiska and Sullivan 2009), the effect these regulations have on waterfowl distribution and behavior, as well as hunter participation and satisfaction are relatively unknown.

We quantified hunting encounters, as well as waterfowl density, behavior, and energy expenditure on wetlands open and closed to hunting during the LGCO in the RWB during springs 2011 and 2012 (Chapters II and III). Wetlands open and closed to hunting (hunt category) were grouped by geographic location, area, and vegetative cover and observed simultaneously to account for potential differences in diurnal time period and weather. We defined season (early and late) based on the decline of light geese observed on study wetlands. Observations considered early season were made during weeks leading up to the point when greater than 95% of all light geese observed on study wetlands each year had left the RWB region. Consequently, hunting encounters recorded on study wetlands open to hunting also declined sharply during late season. Early season encompassed over 90% of hunting encounters recorded on study wetlands and every wetland classified as open to the LGCO was hunted at least once during this time period. We also conducted a mail survey in spring 2012 (Chapter IV) to assess hunter opinions regarding current regulations during the LGCO in the RWB as well as potential hypothetical regulations that could potentially be implemented in the future. Additionally, we evaluated migratory bird hunter opinions regarding potential future management strategies for controlling light goose populations. All means are reported ± standard error. Mail survey means (Chapter IV) we based on a 5-point Likert scale (White et al. 2005), where 1 = "completely disagree or unsupportive" and 5 = "completely agree or supportive."

In Chapter II, we found dabbling duck (*Anas* spp.) densities were greater on wetlands closed to hunting ($\overline{x}$ = 171.44 ± SE 19.15 ducks/ha), compared to wetlands open to hunting ($\overline{x}$ = 51.31 ± SE 5.15 ducks/ha). We found no effect of hunt day in the analysis of dabbling duck densities and similar dabbling duck densities were observed on study wetlands on days open and closed to hunting. We also detected no differences in mean weekly dabbling duck densities among wetlands open to hunting regardless of weekly or cumulative hunting encounter frequency throughout the entire early season. We recorded few greater white-fronted geese (*Anser albifrons*; hereafter white-fronted geese) during our two years of study. Mean number of white-fronted geese observed during early season were 10.70 (± 4.46) and 19.03 (± 6.46) on wetlands open and closed hunting, respectively. In a presence/absence logistic regression model, hunting category was not a predictor for the presence of white-fronted geese. We concluded that an established refuge system during the LGCO in the RWB is an important management strategy for providing non-target waterfowl species disturbance free stopover sites.

In Chapter III, we reported dabbling ducks (mallards [*Anas platyrhynchos*] and Northern pintails [*A. acuta*]) spent more time feeding in wetlands closed to hunting ($\overline{x}$ = 21% ± 0.02) and less time resting ($\overline{x}$ = 29% ± 0.03) during early season 2011, compared to wetlands open to hunting ($\overline{x}$ = 11% ± 0.02) and ($\overline{x}$ = 46% ± 0.02), respectively. However, we detected no difference in dabbling duck behaviors during late season when number of hunting encounters subsided on study wetlands. In 2012 dabbling duck behaviors differed between hunting categories in both early and late seasons. During early season 2012, dabbling ducks spent less time feeding in wetlands closed to hunting ($\overline{x}$ = 26% ± 0.01) and more time resting ($\overline{x}$ = 35% ± 0.03) compared to wetlands open to

hunting (feeding = 37% ± 0.02 and resting = 29% ± 0.02). In late season 2012, dabbling ducks were still spending more time feeding in wetlands open to hunting ($\overline{x}$ = 33% ± 0.03), compared to wetlands closed to hunting ($\overline{x}$ = 26% ± 0.02). There were no differences in behaviors of lesser snow geese or white-fronted geese between hunting categories during early season. We also detected no effects of hunt day in any analyses of dabbling duck behavior or hourly energy expenditure. Since dabbling duck behaviors differed among hunting categories in both early and late seasons in 2012, we concluded that potential differences in habitat among study sites may have influenced our results this year. We also suggest that because we recorded behavior data on species that supplement their diets with waste corn while staging in the RWB (Jorde et al. 1984, Krapu et al. 1995, Pearse et al. 2011), efforts to relate bird behavior, particularly foraging time, to hunting disturbance on RWB wetlands may have been confounded.

In Chapter IV we reported migratory bird hunters strongly agreed that special LGCO regulations established to minimize disturbance to other waterfowl species were important ($\overline{x}$ = 3.7 ± 0.05). Although hunters generally agreed they were satisfied with current regulations, when given alternative choices they were most supportive of an LGCO season open all day, seven days a week, but with more publicly owned wetlands closed to hunting ($\overline{x}$ = 3.06 ± 0.06). Current LGCO regulations in the RWB were the second most supported regulatory alternative ($\overline{x}$ = 2.98 ± 0.06). We conclude there is likely a trade-off for some hunters who would prefer less hunting time if more public wetlands were open to hunting during the LGCO in the RWB. We were not specific about the number of additional wetlands that would be closed if a season open seven days a week were implemented, however this number would likely be relatively small (i.e., ≤

10). In Chapter IV we also found hunters strongly agreed that population control of light geese was an important wildlife management and conservation issue ($\overline{x}$ = 4.6 ± 0.03). However, opinions were fairly neutral when hunters were asked if the LGCO has been effective at controlling light goose populations ($\overline{x}$ = 3.12 ± 0.04). Hunters who indicated participation during the 2012 LGCO in Nebraska were less supportive for any direct control methods presented in the survey, compared to non-participants. We suggest further education through publications and various media outlets that inform hunters and the general public how light goose populations continue to grow (Alisauskas et al. 2011, Alisauskas 2012), continue to destroy arctic habitats (Abraham et al. 2012), and that most means within the realm of sport hunting have proved ineffective at lowering light goose populations. Current LGCO participants also need to be well informed there will likely be minimal changes to current LGCO provisions if any direct control actions are implemented by wildlife agencies (Leafloor et al. 2012). We suggest a more in-depth survey approach covering states in flyways with overabundant light goose populations that gauges not only hunter support, but support of the general public regarding options for directly controlling light geese. Public support will be imperative for wildlife professionals to assess implications of any methods for controlling light goose populations.

Our results suggest the refuge system of wetlands closed to hunting currently in place during the LGCO in the RWB is an important management strategy for providing non-target waterfowl species disturbance-free stopover sites. However, we found no effects of hunt day in any analyses of dabbling duck densities, behavior, or hourly energy expenditure and these metrics were similar among study sites regardless, if the day was

open or closed to the LGCO. We also detected no differences in mean weekly dabbling duck densities among wetlands open to hunting, regardless of weekly or cumulative hunting encounter frequency. Additionally, we found no effects of hunting on the behavior or distribution of white-fronted geese and we speculate that, contrary to previous findings (Gersib et al. 1989, Krapu et al. 1995, Bishop and Vrtiska 2008), a majority of mid-continent white-fronted geese are no longer using the RWB for spring staging. One of the primary reasons restrictive regulations were initially established during the LGCO in the RWB was to protect white-fronted geese from hunting disturbance due to their close association with light geese during this time period (Mark Vrtiska, NGPC, personal communication). The results of our study indicate that providing a LGCO season with more allowable hunting time (i.e., open seven days a week) will have minimal additional impacts to non-target waterfowl using the RWB for spring staging. Additionally, providing more allowable hunting time may increase hunter satisfaction and participation during the LGCO season in the RWB and ultimately aid in the reduction of mid-continent populations of light geese. However, if regulations are changed in the RWB during the LGCO, we suggest an adaptive management approach (Johnson and Williams 1999, Enck et al. 2006) with a continuous evaluation of regulation changes and their effects on waterfowl and hunter participation and satisfaction.

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Appendix 1. Cover letter sent with mail survey to migratory bird hunters following the Light Goose Conservation Order in 2012.

Nebraska Game and Parks Commission
2200 N. 33rd St. • P.O. Box 30370 • Lincoln, NE 68503-0370 • Phone: 402-471-0641 • Fax: 402-471-5528

2012 Light Goose Conservation Order Survey
33-479 / rev.2/12

Dear Light Goose Hunter:

The Nebraska Game and Parks Commission is conducting this survey to evaluate the effect of the Light Goose (Snow, Blue and Ross's geese) Conservation Order on light goose populations and assess hunter satisfaction and opinions of current and potential, future regulations. You have been randomly selected to participate in this survey and we are very interested in hunt/harvest information and your opinion.

Please provide information that reflects **only your personal** hunts/harvest and opinions. **Please DO NOT** give us the hunts/harvests or opinions of other hunters. Your name and information will remain confidential.

Survey questions are regarding special regulations in the Rainwater Basin (Zones 1 and 2; see below for zone boundaries) that have been put into place to limit disturbance to other migratory birds, as well as future methods for controlling light goose populations.

Please circle the answer you agree most with for each statement and there are no right or wrong answers. **It will be extremely helpful if you can reply to this survey as soon as possible.** A postage-paid, pre-addressed envelope is enclosed for your convenience. Simply complete the survey, place it in the envelope, and put it in the mail.

Thank you for helping us better manage our waterfowl resources.

Sincerely,

Mark Vrtiska, PhD
Waterfowl Program Manager
Wildlife Division

The University of Missouri is in collaboration with the Nebraska Game and Parks Commission on this survey and your participation is voluntary. You may refuse to participate in the study or may withdraw at any time. You can refuse to answer any question on the survey. Should you have any questions regarding your rights as a participant in the study, please contact the University of Missouri Institutional Review Board, (573) 882-9585. If you have any questions concerning the survey or the project of which it is part please contact Andrew Dinges, (402) 350-8481 or ajdr43@mail.mizzou.edu

The term "light geese" refers to Snow, Blue and Ross's geese.

Appendix 2. Mail survey sent to migratory bird hunters following the Light Goose Conservation Order in 2012. Mean scores (± SE) and frequencies of responses rounded to nearest (%) are reported for each Likert type survey item. Mean scores based on 1-5 scale, where 1 = "completely disagree or completely unsupportive", 5 = "completely agree or completely supportive" (survey modified from original version due to margin differences).

Did you hunt light geese in Nebraska during the February 6 – April 15, 2012, season (spring 2012)?

☐ Yes ☐ No

Please indicate your residence: State: _____ County: _____

Based on the map below, please report the number of days <u>you</u> hunted light geese and the number of light geese <u>you</u> harvested during the February 6 – April 15, 2012, season.

****Only report your harvest, not the harvest of you friends or relatives****

Zone 1		Zone 2		Zone 3	
No. of Days Hunted	**Light Geese Harvested**	**No. of Days Hunted**	**Light Geese Harvested**	**No. of Days Hunted**	**Light Geese Harvested**

How many light geese did <u>you</u> shoot, but not retrieve? _____

Indicate which methods you used to hunt light geese:

Indicate with a check mark (√) or X

Method	Yes	No
Electronic Call		
Unplugged Shotgun		
30 minutes after Sunset		

Based on the methods you used and the number of light geese you harvested (question #3), please indicate the number of light geese taken:

a. with the aid of an electronic caller _____.
b. with the fourth, fifth, or sixth shotgun shell _____.
c. 30 minutes after sunset _____.

The following questions pertain to hunting participation and current regulations during the Light Goose Conservation Order (LGCO) in the Rainwater Basin (RWB) of Nebraska. Please circle the answer you agree with most for each statement.

Hunting participation and regulations	Complete Disagree	Generally Disagree	Neutral	Generally Agree	Completely Agree	No Opinion	Mean Score
1) It is important that special regulations are in place to minimize disturbance to other waterfowl species during the LGCO in the RWB.	7	9	16	26	26	16	3.7 ± 0.05
2) I am satisfied with current regulations (four days open to hunting and 16 public wetlands closed entirely) during the LGCO in the RWB.	8	13	20	20	13	25	3.2 ± 0.05
3) I would participate more frequently during the LGCO in the RWB if existing regulations were simplified.	6	8	24	20	16	27	3.4 ± 0.05
4) I would participate less frequently during the LGCO in the RWB if existing regulations were more complex.	11	8	19	15	19	27	3.3 ± 0.06
5) I participate fewer days now during the LGCO in the RWB than I have in previous years.	8	6	22	11	16	37	3.3 ± 0.06
6) I primarily hunt public land while participating in the LGCO in the RWB.	19	10	16	11	9	34	2.7 ± 0.06
7) Crowding from other hunters causes me to participate less frequently during the LGCO in the RWB.	15	11	18	12	8	35	2.8 ± 0.06
8) If there is a trade-off between allowable hunting time during the week and the number of public wetlands closed to hunting (currently 16) I would prefer to have more public wetlands closed to hunting to increase allowable hunting time in the RWB.	8	13	22	14	7	36	3.0 ± 0.05
9) I would participate more frequently during the LGCO in the RWB if there was a program for access to allow hunting on private land, but with more public basins closed to hunting.	9	12	22	15	11	31	3.1 ± 0.05
10) I would participate more frequently during the LGCO in the RWB if there was a program for access to allow hunting on private land, but with fewer hunting days during the week.	13	17	23	10	5	31	2.7 ± 0.05

Hunting participation and regulations (continued)	Completely Disagree	Generally Disagree	Neutral	Generally Agree	Completely Agree	No Opinion	Mean Score
11) As a **non-resident hunting in Nebraska,** I would participate more frequently during the LGCO in the RWB if a license was available for the entire LGCO that was less expensive than the annual non-resident hunting license.	8	6	11	19	38	18	3.9 ± 0.10
12) The distance I have to travel to get to hunting locations causes me to participate less during the LGCO in the RWB.	8	9	18	21	19	26	3.5 ± 0.05
13) The cost (gas, decoys, ammunition etc.) associated with spring light goose hunting causes me to participate less during the LGCO in the RWB.	8	11	17	23	19	23	3.4 ± 0.05
14) I participate less now during the LGCO order in the RWB than in past years because light geese have become increasingly difficult to harvest.	10	12	21	14	11	32	3.1 ± 0.06

Below is a list of 6 possible sets of regulations that could potentially be used to regulate hunting during the LGCO in the RWB. Current Regulations include 16 public areas closed to hunting. Please circle the answer you agree with most for each statement.

Potential Regulations	Completely Disagree	Generally Disagree	Neutral	Generally Agree	Completely Agree	No Opinion	Mean Score
15) Open 7 days, open all day, but more public basins closed to hunting than current regulations.	10	16	18	15	13	29	3.1 ± 0.06
16) Open 7 days, closed after 1 p.m., but more public basins closed to hunting than current regulations.	21	22	17	8	3	30	2.3 ± 0.05
17) Open 5 days (Tues-Thurs, Sat/Sun), open all day, but a few more public basins closed to hunting than current regulations.	14	18	21	13	4	31	2.6 ± 0.05
18) Open 5 days (Tues-Thurs, Sat/Sun), closed after 1 p.m., but a few more public basins closed to hunting than current regulations.	21	21	20	6	2	31	2.2 ± 0.05
19) Open 4 days (Tues/Wed, Sat/Sun) open all day (current regulations).	12	12	19	17	9	31	3.0 ± 0.06
20) Open 4 days (Tues/Wed, Sat/Sun) closed after 1 p.m.	25	19	18	5	2	31	2.1 ± 0.05

The following questions pertain to future management of light goose populations by wildlife officials. Please circle the answer you agree with most for each statement.

Future management of light goose populations	Completely Disagree	Generally Disagree	Neutral	Generally Agree	Completely Agree	No Opinion	Mean Score
21) The population control of light geese is an important wildlife management and conservation issue.	1	1	3	20	67	9	4.6 ± 0.03
22) Since being enacted in 1999, the LGCO has been effective at controlling light goose populations.	6	19	23	26	8	19	3.1 ± 0.04
23) The liberalization of hunting regulations during the LGCO, such as unplugged shotguns, electronic calls, and extended shooting hours increases my harvest of light geese.	2	5	13	23	35	22	4.1 ± 0.04
24) Further liberalization of regulations, such as live decoys or baiting would increase my participation during the LGCO.	14	17	23	11	17	18	3.0 ± 0.05
25) I am capable of harvesting more light geese during the LGCO, but limit my take due to the taste of light goose meat.	25	17	18	11	6	23	2.4 ± 0.05
26) I would support legalizing the commercial trade of harvested light geese.	27	13	16	18	12	15	2.7 ± 0.06
27) I would support wildlife officials using alternative methods other than spring hunting to control light goose populations.	17	15	19	21	15	13	3.0 ± 0.05
28) Processing light geese that have been directly harvested by wildlife officials for human consumption or other uses is important to me.	11	7	25	24	14	19	3.3 ± 0.05

Below is a list of 5 possible alternatives that wildlife officials could potentially use to control light goose populations. Please circle the answer you agree with most for each statement.

Alternatives for light goose control	Completely Disagree	Generally Disagree	Neutral	Generally Agree	Completely Agree	No Opinion	Mean Score
29) Selectively shooting light geese on arctic breeding grounds.	22	17	18	19	11	13	2.8 ± 0.05
30) Trapping and euthanizing flightless light geese on arctic breeding grounds.	29	17	14	18	9	13	2.6 ± 0.05
31) Selectively shooting light geese on migration and wintering areas.	14	8	15	32	19	12	3.4 ± 0.05
32) Trapping and euthanizing light geese on migration and wintering areas.	30	20	14	15	7	13	2.4 ± 0.05
33) Euthanizing light geese on migration and wintering areas using bait with approved chemicals.	48	20	9	6	4	12	1.8 ± 0.04

Appendix 3. Text on reminder post card sent to migratory bird hunters 10 days after the initial distribution of mail survey following the Light Goose Conservation Order in 2012.

Dear Nebraska Hunter,

Recently, you were mailed a survey requesting your information and opinions on the Light Goose Conservation Order (LGCO) in Nebraska by the Nebraska Game & Parks Commission (Commission). The Commission is conducting this survey in an effort to better understand harvest, participation, and hunter preferences in the LGCO.

Your comments are important in assisting managers to make decisions about the LGCO in Nebraska. If you have completed and returned the survey, we appreciate your input and thank you for your time. If you haven't done so yet, please take this opportunity to share your information. The survey should take approximately 5-10 minutes to complete and is strictly confidential.

If you have any questions about the survey, or would like another copy, please contact the Commission at (402) 471-5597. Thank you for your time.

Mark Vrtiska, Ph.D.
Waterfowl Program Manager
Nebraska Game and Parks Commission