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ABUNDANCE AND DISTRIBUTION OF LESSER SNOW AND ROSS’S GEESE IN THE RAINWATER BASIN AND CENTRAL PLATTE RIVER VALLEY OF NEBRASKA

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ABSTRACT—The number of lesser snow geese (Chen caerulescens) and Ross’s geese (C. rossii), hereinafter called “light geese,” staging during spring in the Rainwater Basin and Central Platte River Valley of south-central Nebraska has dramatically increased since the late 1980s. However, there has been no documentation of the abundance or distribution of light geese across the Rainwater Basin and Central Platte River Valley and the relationship of distribution to conservation-order activities. We used aerial transect surveys and distance sampling methodology to estimate abundance and distribution of light geese in the Rainwater Basin and Central Platte River Valley in the spring of 2001, 2002, and 2003. In 2001 at peak migration, we estimated approximately 7.3 million light geese in the Rainwater Basin and Central Platte River Valley. In 2002 and 2003 there were approximately 1.2 million and 1.6 million light geese at peak migration, respectively. Distribution did not appear to change in relation to light goose conservation-order activities. However, there was an increased use of the Central Platte River Valley during 2002 and 2003 due to dry conditions. The Rainwater Basin and Central Platte River Valley have become a major spring staging area for light geese. Abundance and distribution appear to be related to water conditions and migration chronology.

Key Words: Chen caerulescens, Chen rossii, lesser snow geese, Ross’s geese, Rainwater Basin, Platte River, migration

INTRODUCTION

Breeding colonies of midcontinent lesser snow geese (Chen caerulescens) and Ross’s geese (C. rossii) have increased to unprecedented levels and have caused extensive damage to arctic and subarctic ecosystems (Ankney 1996; Abraham and Jefferies 1997; Didiuk et al. 2001; Jefferies et al. 2004). Stress-related demographic and physiological responses have been documented among goose populations where damage has occurred, and concerns for other species have been reported (Cooch et al. 1991; Williams et al. 1993; Abraham and Jefferies 1997; Jefferies et al. 2004). To reduce light goose populations and halt damage to arctic and subarctic habitats, the U.S. Fish and Wildlife Service and the Canadian Wildlife Service initiated a conservation order in 2000 in the Mississippi and Central flyways to increase harvest of light geese. The conservation order allows for the taking of light geese after March 10 and/or when all other waterfowl seasons have closed. The order also allows the use of unplugged shotguns and electronic calls and allows the taking of light geese 30 minutes past sunset.

The Rainwater Basin and Central Platte River Valley of south-central Nebraska are situated in the middle of the Central Flyway and are an important spring-staging area for waterfowl, particularly for mallards (Anas platyrhynchos), northern pintails (A. acuta), greater white-fronted geese (Anser albifrons) (Gersib et al. 1992), and the midcontinent population of sandhill cranes (Grus canadensis) (Tacha et al. 1994). Migrating waterfowl obtain nutrient reserves in the Rainwater Basin to continue migration and for reproduction (Gersib et al. 1992; Klaassen et al. 2006).

In the late 1980s and early 1990s, relatively high numbers of light geese also began staging in the Rainwater Basin and Central Platte River Valley (N. Lyman, Nebraska Game and Parks Commission, personal observation). With implementation of the conservation order to increase light goose harvest, there was concern about...
the possible negative impacts of conservation-order activities to nontarget species within the Rainwater Basin and Central Platte River Valley (Davis 2001; Krapu et al. 2004). Specifically, increased disturbance from conservation-order activities may limit the amount of nutrient reserves that nontarget would acquire. Therefore, the U.S. Fish and Wildlife Service and the Nebraska Games and Parks Commission established regulations (e.g., region closures) that attempted to maximize harvest of light geese while minimizing impacts to nontarget waterfowl species.

Because light geese in the Rainwater Basin and Central Platte River Valley may compete with other waterfowl and sandhill cranes for resources, a better understanding of how conservation-order regulations affected light geese movements, and consequently other species, was important. Objectively and efficiently assessing distribution and relative abundance of the staging light goose population in the Rainwater Basin and Central Platte River Valley was critical in evaluating the impact of conservation-order activities on large-scale movements of light geese. If conservation-order activities appeared to impact distribution of light geese, then appropriate changes to regulations could be employed to negate movement. Therefore, we used aerial transect surveys to determine spatial distribution and relative abundance of staging light geese in the Rainwater Basin and Central Platte River Valley in the spring of 2001, 2002, and 2003.

**METHODS**

**Study Area**

The Rainwater Basin encompasses 10,878 km² of flat to gently rolling loess plains dotted with natural wetlands formed from a combination of poorly developed drainage and clay-bottomed wetlands (McMurtrey et al. 1972; LaGrange 2005). Palustrine wetlands currently cover 11,436 ha of the Rainwater Basin (Smith and Higgins 1990). The area is intensively farmed and is dominated by corn and soybean production (Nebraska Agricultural Statistics Service 2001).

The Central Platte River Valley lies just north of the Rainwater Basin (Fig. 1) and is comprised of a braided river of multiple channels and associated oxbow lakes and wet meadows (LaGrange 2005). Gravel pit and sand mining operations also occur in the Central Platte River Valley, which provide deepwater habitats. The river valley also is dominated by corn and soybean production (Nebraska Agricultural Statistics Service 2001).

The zone boundaries established for the light goose conservation order increased the study area size to approximately 16,107 km² (Fig. 1). Zone 1 (eastern Rainwater Basin) covered 8,860 km² (66%) of the study area, while Zone 2 (western Rainwater Basin) encompassed 4,496 km² (34%) of the study area. The Central Platte River Valley was defined as that area lying between U.S. Highway 283 on the west, Nebraska Highway 92 on the east, U.S. Highway 30 to the north, and a line 8 km south of the south channel of the Platte on the south (Fig. 1). The Central Platte River Valley encompassed 2,749 km² of the study area, of which 1,942 km² occurred west of U.S. Highway 281 and 807 km² occurred east of U.S. Highway 281.

Zone 1 was open to conservation-order activities each year from 2000 to 2003, but Zone 2 was open in 2000 and 2002 only (Table 1). Both zones were only open to conservation-order activities on Wednesday, Thursday, Saturday, and Sunday. Conservation-order activities were allowed on all private and public land except those specifically closed by regulation. Zone 3 included all of Nebraska outside this delineated road system around the Rainwater Basin, including the remainder of the middle part of the Central Platte River Valley, and was open to conservation-order activities without special restrictions.

**Aerial Surveys**

We attempted total coverage of the Rainwater Basin and Central Platte River Valley using strip surveys conducted with one or two high-wing airplanes and methodology similar to that used in distance sampling (Buckland et al. 1993; Guenzel 1997). Two airplanes were used for the survey on March 14, 2001, but all remaining surveys were conducted using one airplane. The survey on March 30, 2001, was only partially completed due to the onset of inclement weather. We initiated surveys when weather conditions allowed and when there were adequate numbers of light geese present in the Rainwater Basin or Central Platte River Valley.

Surveys followed the methods of Guenzel (1997) with transects 16 km apart that were flown at 900 m to 1,068 m above ground level (AGL) when one aircraft was used (Fig. 2), except for the survey on March 14, 2001, when transects were 8 km apart, flown at 610 m AGL, and two aircraft were used. We assumed detection probabilities for all flocks were equal to one because transects were
Figure 1. Study area for our examination of the distribution and abundance of light geese (lesser snow and Ross’s geese) in the Rainwater Basin and Central Platte River Valley of south-central Nebraska, including location of Platte River.

<table>
<thead>
<tr>
<th>Year</th>
<th>Hunting regime</th>
<th>Water condition$^a$</th>
<th>Arrival date$^b$</th>
<th>Departure date$^b$</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>Zone 2 closed</td>
<td>Wet</td>
<td>March 7</td>
<td>March 22</td>
</tr>
<tr>
<td>2002</td>
<td>Zone 2 open</td>
<td>Dry</td>
<td>February 14</td>
<td>March 22</td>
</tr>
<tr>
<td>2003</td>
<td>Zone 2 closed</td>
<td>Dry</td>
<td>March 7$^c$</td>
<td>March 21</td>
</tr>
</tbody>
</table>

Note: Light geese are lesser snow and Ross’s geese. See Figure 1 for zone boundaries.

$^a$Water condition was measured on amount of precipitation received at Hastings, NE, October 1 through March 1 (National Oceanic and Atmospheric Administration 2009).

$^b$Arrival and departure date were subjectively assessed throughout region.

$^c$Light geese used areas along the Platte River primarily west of U.S. Hwy 281 in February and March, bypassing much of the western Rainwater Basin due to a lack of open water.
spaced such that light goose flocks in the study area were likely to be observed during surveys, and large, predominantly white, light goose flocks were easily observed. Transects were laid out northeast to southwest in the morning, north to south at midday, and southwest to northeast in the afternoon in order to minimize sun glare (Fig. 2). When two aircraft were used, aircraft started simultaneously on transects near the boundary of Zones 1 and 2 and then flew toward the east and west boundaries, respectively, of the study area. To avoid partial coverage, we attempted flights as soon as the majority of snow cover had disappeared and on the first day with acceptable cloud ceilings and weather conditions. We attempted to fly each week there were large numbers of birds in the study area and to cover the area in one day.

Airplanes were equipped with a GPS unit, an altimeter capable of operating at $\geq 610$ m AGL, an onboard computer tied to the GPS unit, and indicator lines for determining distance bands placed on the wing struts (Guenzel 1997). Two teams of two observers were assigned to each airplane for each survey. One pair of observers was in the plane during the survey flights and the pilot(s) did not officially observe. Each pair of observers flew for three- to four-hour time periods and then switched with the other pair to minimize missed flocks due to observer fatigue (Guenzel 1997). We also attempted to complete most of our surveys between 1000 and 1600 hrs to reduce sun glare and increase the likelihood that light goose flocks would be loafing on water and not moving from feeding to loafing sites.

We defined flocks as contiguous groups of $\geq 100$ light geese occurring between the ground and the level of the airplane. All flocks observed on the ground were counted. When a flock was observed on the ground and flushed at the approach of the airplane, the location where they flushed was recorded. Flocks not observed on the ground prior to flushing were recorded as flying flocks and not included in counts. Observers related light goose flocks to the pilot as soon as they were perpendicular to the plane, according to the appropriate distance band and the estimated flock size category. Flocks were categorized into one of five flock sizes: (1) 100-1,000; (2) 1,000-5,000; (3) 5,000-10,000; (4) 10,000-50,000; and (5) $>50,000$. Although we attempted to reduce variation of estimates of flock sizes by having observers categorize them, an unclear estimate of flock size (e.g., 2,500) also was obtained when possible. Flock size and distance band were then entered into the computer by the pilot. GPS coordinates were automatically obtained when data were entered into the computer to obtain distribution information.

Because accuracy in estimating numbers of birds in large flocks is less than with smaller flocks (Chattin 1952; Strong et al. 1991), we photographed flocks that we considered difficult to estimate due to either sheer abundance or density issues (e.g., different altitudes of geese flying in the same flock). A 35 mm camera fitted with 70-300 or 100-300 mm zoom lenses and 100 ASA film was used, and we deviated from transect lines when necessary to obtain quality photographs.

Because the blue morphological forms of snow and Ross’s geese could not be readily observed from the plane, only the white morphological forms were estimated or counted. We obtained percentage of blue morph birds in light goose flocks from ground surveys conducted concurrently with aerial surveys to account for the blue morphs in flock counts. The percentage of blue morphs in light goose flocks was estimated using a spotting scope. The scope was left in one location randomly within a flock of light geese. Within the field of view, the
The total number of light geese and the number of blue morphs were counted on separate hand tallies. This count was repeated up to four more times randomly within the flock.

Given total coverage, we estimated abundance by adding all flock totals using the following, in descending order: counts obtained from photos, flock size estimates, or the midpoint of the flock category. To account for blue morphs, the abundance estimate was divided by the proportion of white morphs from the ground surveys and then added to the total number for an overall estimate of light geese.

To examine changes in abundance between the Rainwater Basin and Central Platte River Valley, we designated the river valley to be the area 8 km south of the southernmost channel of the Platte River to U.S. Highway 30 to the north and within the Rainwater Basin study area (Fig. 2). This area encompasses the main staging area and distances for foraging and roosting used by staging midcontinent sandhill cranes (Iverson et al. 1987).

**RESULTS**

**Migration Chronology and Water Conditions**

Migration chronology and availability of water in the study area varied by year and within year (Table 1). Differences in timing of arrival of light geese were due to fluctuations in temperatures that determined availability of open water for roosting. Light geese did not arrive in the Rainwater Basin until early or mid-March in 2001 and 2003 (Table 1). Conversely, a relatively early migration was observed in 2002, although cold temperatures and a snowstorm on March 1 forced light geese to migrate south again. Light geese began returning to the Rainwater Basin on approximately March 14. While arrival of light geese into the Rainwater Basin varied, departure from the Rainwater Basin was similar in all three years (Table 1).

Although we did not quantify the amount or distribution of water in the Rainwater Basin, we subjectively classified the availability by visually observing wetlands throughout the region (Table 1). In 2001 all wetland basins across the Rainwater Basin were full from natural precipitation, and other shallow, sheet-water areas also were available. Water conditions deteriorated in 2002 from 2001 and more so in 2003, when dry conditions existed (Table 1). From October to February, precipitation in Adams County, in the middle of the Rainwater Basin, was 17.8 cm in 2001, 9.0 cm in 2002, and 14.7 cm in 2003 (National Oceanic and Atmospheric Administration 2009). Based on a separate aerial survey conducted in mid-March, there were 3,400, 1,500, and 1,200 ha of flooded wetland habitat available in 2001, 2002, and 2003, respectively, on public wetlands (J. Drahota, Fish and Wildlife Service, Kearney, NE). In 2002 and 2003 some wetlands were pumped to augment the few wetlands that were full via precipitation.

**Aerial Surveys**

The estimated number of light geese using the Rainwater Basin and the Central Platte River Valley in 2001-2003 ranged from 1.2 million to 7.3 million (Table 2). The highest total estimated number of light geese occurred in 2001 and the lowest was in 2002 (Table 2). Abundance of light geese varied between Zone 1 and Zone 2 within and among years (Table 2). Abundance of light geese also varied when Zone 2 was closed to conservation-order activities (Table 2). Perhaps of more interest, light geese were present in lower numbers in Zone 2 than Zone 1 during 2002, a year when conservation-order activities were allowed.

The percentage of light geese observed in the Central Platte River Valley increased steadily from 2001 to 2003 (Table 3). Relatively few light geese were observed in the river valley during 2001, but at peak migration in 2003, almost 30% of all light geese counted were located in the Central Platte River Valley (Table 3). Indeed, the river valley contained more light geese in all surveys in 2003 than Zone 1 (Table 3).

**DISCUSSION**

Results from these surveys represent the first estimates of light goose abundance in the Rainwater Basin and Central Platte River Valley during spring migration. The estimated 7 million light geese using the Rainwater Basin and the Central Platte River Valley in 2001 is more than three times higher than the count from the Mid-Winter Survey for the Mississippi and Central Flyways obtained in that year (Kruse 2004). This estimate also suggests that the majority of midcontinent lesser snow geese and perhaps Ross’s geese staged in the Rainwater Basin in 2001. Additionally, our aerial surveys were only day-specific, and did not account for turnover rates. Thus, the absolute number of light geese using the Rainwater Basin and Central Platte River Valley is much higher. Although fewer light geese used the Rainwater Basin and Central Platte River Valley in 2002 and 2003, both regions have become a major staging area for spring-migrating lesser snow and Ross’s geese in North America. However, we
### TABLE 2
COMPARISON OF LIGHT GOOSE ABUNDANCE IN CONSERVATION-ORDER ZONES 1 AND 2 FROM AERIAL TRANSECT SURVEYS, RAINWATER BASIN OF NEBRASKA, FEBRUARY-MARCH 2001-2003

<table>
<thead>
<tr>
<th>Date</th>
<th>Zone 2 status</th>
<th>Zone 2</th>
<th>Zone 1</th>
<th>Total</th>
<th>Percentage in Zone 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>March 14, 2001</td>
<td>Closed</td>
<td>4,902,066</td>
<td>2,445,323</td>
<td>7,347,389</td>
<td>67</td>
</tr>
<tr>
<td>March 24, 2001</td>
<td>Closed</td>
<td>284,435</td>
<td>316,935</td>
<td>601,370</td>
<td>47</td>
</tr>
<tr>
<td>March 30, 2001</td>
<td>Closed</td>
<td>124,678</td>
<td>98,629</td>
<td>223,307</td>
<td>56</td>
</tr>
<tr>
<td>February 16, 2002</td>
<td>Open</td>
<td>47,339</td>
<td>280,000</td>
<td>327,339</td>
<td>15</td>
</tr>
<tr>
<td>February 22, 2002</td>
<td>Open</td>
<td>218,331</td>
<td>419,185</td>
<td>636,516</td>
<td>34</td>
</tr>
<tr>
<td>March 12, 2002</td>
<td>Open</td>
<td>509,839</td>
<td>717,129</td>
<td>1,226,968</td>
<td>42</td>
</tr>
<tr>
<td>March 22, 2002</td>
<td>Open</td>
<td>74,646</td>
<td>82,508</td>
<td>157,154</td>
<td>48</td>
</tr>
<tr>
<td>February 19, 2003</td>
<td>Closed</td>
<td>70,896</td>
<td>44,803</td>
<td>115,699</td>
<td>61</td>
</tr>
<tr>
<td>March 7, 2003</td>
<td>Closed</td>
<td>208,669</td>
<td>72,751</td>
<td>281,420</td>
<td>74</td>
</tr>
<tr>
<td>March 14, 2003</td>
<td>Closed</td>
<td>598,812</td>
<td>1,041,613</td>
<td>1,640,426</td>
<td>37</td>
</tr>
<tr>
<td>March 21, 2003</td>
<td>Closed</td>
<td>114,627</td>
<td>160,449</td>
<td>275,076</td>
<td>42</td>
</tr>
</tbody>
</table>

Note: Light geese are lesser snow and Ross’s geese.

### TABLE 3
COMPARISON OF LIGHT GOOSE ABUNDANCE FROM AERIAL TRANSECT SURVEYS IN THE RAINWATER BASIN AND CENTRAL PLATTE RIVER VALLEY AND CONSERVATION-ORDER ZONES 1 AND 2, NEBRASKA, FEBRUARY-MARCH 2001-2003

<table>
<thead>
<tr>
<th>Date</th>
<th>Zone 2 status</th>
<th>CPRV&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Zone 1</th>
<th>Zone 2</th>
<th>Total</th>
<th>Percentage in CPRV</th>
</tr>
</thead>
<tbody>
<tr>
<td>March 14, 2001</td>
<td>Closed</td>
<td>890,295</td>
<td>4,053,787</td>
<td>2,403,306</td>
<td>7,347,389</td>
<td>12</td>
</tr>
<tr>
<td>March 24, 2001</td>
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<td>2,661</td>
<td>281,774</td>
<td>316,935</td>
<td>601,370</td>
<td>&lt;1</td>
</tr>
<tr>
<td>March 30, 2001</td>
<td>Closed</td>
<td>9,678</td>
<td>119,839</td>
<td>93,790</td>
<td>223,307</td>
<td>4</td>
</tr>
<tr>
<td>February 16, 2002</td>
<td>Open</td>
<td>1,936</td>
<td>47,016</td>
<td>278,387</td>
<td>327,339</td>
<td>&lt;1</td>
</tr>
<tr>
<td>February 22, 2002</td>
<td>Open</td>
<td>124,516</td>
<td>101,815</td>
<td>409,185</td>
<td>636,516</td>
<td>20</td>
</tr>
<tr>
<td>March 12, 2002</td>
<td>Open</td>
<td>252,742</td>
<td>303,952</td>
<td>670,274</td>
<td>1,226,968</td>
<td>21</td>
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<tr>
<td>March 22, 2002</td>
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<td>57,250</td>
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<td>80,613</td>
<td>157,154</td>
<td>36</td>
</tr>
<tr>
<td>February 19, 2003</td>
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<td>41,343</td>
<td>29,552</td>
<td>44,803</td>
<td>115,699</td>
<td>36</td>
</tr>
<tr>
<td>March 7, 2003</td>
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<td>14,366</td>
<td>72,751</td>
<td>281,420</td>
<td>69</td>
</tr>
<tr>
<td>March 14, 2003</td>
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<td>527,320</td>
<td>160,746</td>
<td>952,260</td>
<td>1,640,426</td>
<td>32</td>
</tr>
<tr>
<td>March 21, 2003</td>
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<td>100,522</td>
<td>14,478</td>
<td>160,076</td>
<td>275,076</td>
<td>37</td>
</tr>
</tbody>
</table>

Notes: Light geese are lesser snow and Ross’s geese.

<sup>a</sup>Central Platte River Valley.
note that 2001 should be considered an anomaly in terms of one-day totals of light geese in the both regions. Since 2001 there have not been similar numbers of light geese in this region at one time (M. Vrtiska, Nebraska Game and Parks Commission, personal observation). Likewise, the combination of a relatively late migration and water conditions have not been experienced either. One-day totals of light geese in the Rainwater Basin and Central Platte River Valley are more similar to those observed in 2002 and 2003 (M. Vrtiska, Nebraska Game and Parks Commission, personal observation).

No clear pattern of use by light geese of Zone 2 emerged when the zone was closed and open to conservation-order activities. Additionally, movement of neck-collared snow geese did not indicate consistent movement into Zone 2 when closed (Nebraska Game and Parks Commission, unpublished data). However, Bechet et al. (2003) found that hunting affected the movements of greater snow geese (C. c. atlanticus). The inconsistent pattern we observed may have been a result of Zone 1 wetlands closed to conservation-order activities, restriction of days open to conservation-order activities, and water availability that provided some spatial and temporal refuge to light geese and tempered conservation-order-related disturbance (Madsen 1998).

Our observations also lead us to hypothesize that water availability, both in quantity and quality (i.e., ice-free) is an important factor in settling patterns of light geese when flocks are first arriving in Nebraska. We also believe the increasing use of the Central Platte River Valley was due to lack of water in the Rainwater Basin during 2002 and 2003. Initial observations of light geese in 2002 and 2003 were on sandpit lakes along the Central Platte River Valley that were the first to have open water (S. Sullivan, personal observation).

We did not attempt to quantify the amount or distribution of water and conservation-order activities in the Rainwater Basin and Central Platte River Valley. Future surveys need to incorporate these variables to gain better understanding of light goose distribution in this region. Long-term monitoring of light goose abundance and distribution in the Rainwater Basin and Central Platte River Valley also is needed to elucidate patterns of use in relation to water availability and conservation-order activities. The short time period of our study did not cover the spectrum of water availability and conditions that can occur in this region. Additionally, changing strategies (e.g., days and areas open) of conservation-order activities in this region also may provide insights into light goose distribution patterns in relation to disturbance.

Relatively abundant waste grain is a major reason why light geese and other waterfowl stage in the Rainwater Basin and Central Platte River Valley (Krapu et al. 2004). Because it was outside the scope of this project, we did not specifically measure waste grain availability or distribution in the Rainwater Basin and Central Platte River Valley. Total hectares planted to corn did not appear to vary considerably during the study in a manner that would have greatly influenced light goose distribution. Total hectares planted to corn for Clay County (eastern Rainwater Basin) and Phelps County (western Rainwater Basin) ranged from 57,063-60,300 and 61,500-70,800 ha, respectively (U.S. Department of Agriculture, National Agricultural Statistical Service 2009). Furthermore, we attempted to conduct most of the surveys during periods when light geese were roosting on water and not in feeding flocks.

Light goose flocks can reach large and impressive sizes. Based on our photographs, we found a tendency for observers to overestimate the number of birds in large flocks. Photographing large flocks made it possible to rectify counts that would have greatly influenced our estimates. Flying off transects to photograph each flock would have precluded us from completing the survey within a day. We believe that having observers first categorize flock size before making a more specific estimate helped in reducing variation by framing the size of light goose flocks.

Management Recommendations

The relatively large size of the Rainwater Basin and the unpredictable, highly mobile light goose flocks prone to occurring in large clusters in varied habitats prohibit use of ground surveys to estimate abundance and distribution. Use of aerial transects was suitable for this region and we recommend future surveys in this region to help elucidate variables that may affect light goose abundance and distribution, including any future changes to conservation-order regulations (e.g., number of closed areas) or level of activities.

Future surveys in this region should use two aircraft flying transects 8 km apart at 610 m AGL to increase the efficiency of the survey and allow completion of the survey in one day. We also found that transects placed 8 km at 610 m AGL provided the best coverage and view to observe flocks of light geese. If one aircraft is used, then we recommend transects at 16 km apart flown at 900 m AGL. Additionally, photograph of all sizes of light goose flocks observed would increase accuracy of counts and
provide estimates of observer error. This or other methods of correcting counts need to be continued on future surveys to increase accuracy of estimated abundances.

Current conservation-order regulations and level of activities in the Rainwater Basin and Central Platte River Valley do not appear to have affected light goose abundance and distribution. Future changes in conservation-order regulations or levels of activities may affect light goose populations and should consider future aerial surveys as part of an assessment in those changes. Our techniques were not adequate to address changes in abundance or distribution in other goose or waterfowl populations that may be affected by light geese or conservation-order activities. Finally, negative impacts of conservation-order activities on nontarget species also may be occurring at smaller scales than measured in our study.

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