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ABSTRACT—The Platte rivers and associated habitats are major wintering areas for Canada geese (*Branta canadensis*) in Nebraska. The objective of this study was to examine changes in abundance and distribution of Canada geese along the Platte River system during 1960-2000. We used counts of Canada geese based on aerial surveys from the annual Mid-Winter Survey (MWS). The entire lengths of the North and South Platte rivers and the Platte River were surveyed, and counts of Canada geese were made by visual estimation. We examined changes in goose numbers for the North and South Platte rivers, and divided the Platte River into two main sections (Central and East) over four time periods (i.e., decades). There appeared to be change in the distribution of Canada geese along the Platte River system; however, wintering Canada geese increased (>500%) on all river sections from the decades 1960-1969 to 1990-2000. Changes in the distribution and abundance of wintering Canada geese along the Platte reflect increases in populations in the Central Flyway and habitat changes that have benefited wintering geese.

Key Words: *Branta canadensis*, Canada geese, Mid-Winter Survey, Nebraska, Platte River

Introduction

Canada geese (*Branta canadensis*) are an important resource for hunting and viewing, and for some people they symbolize nature and wildlife

(Bellrose 1980; Smith et al. 1999). To meet the demand for this resource, efforts to restore giant Canada geese (*Branta canadensis maxima*) in the Central Flyway (e.g., Dill and Lee 1970; Lee et al. 1984) and across the United States were initiated in the 1960s. Most of these programs continued through the 1980s and into the 1990s and were quite successful, resulting in increases of resident populations (Nelson and Oetting 1998; Gabig 2000). Additionally, populations of migrant Canada geese, including the Hi-Line, Tall Grass Prairie, and Short Grass Prairie populations that migrate through and winter in Nebraska, have increased in recent years (Hines et al. 2000; Nieman et al. 2000; Kruse and Sharp 2002). Although the vast majority of these populations winter outside Nebraska (Rutherford 1965; Grieb 1968; Bellrose 1980), some portion of those populations also may winter in Nebraska.

Although increases in Canada goose populations have led to more opportunities for consumptive and nonconsumptive uses, they also have led to more conflicts with humans (Smith et al. 1999). States in the Central Flyway have experienced increases in problems with nuisance Canada geese, primarily involving resident populations (Gabig 2000). Increases in problems have led to increases in expenditures to deal with problem geese. For example, from 1999 to 2002, an average of approximately 6,500 manpower hours and over $279,000 have been needed annually to deal with nuisance complaints (A. Smith, South Dakota Department of Game, Fish and Parks, unpublished report).

Recent increases in Canada goose populations across the United States and Canada are well documented (e.g., Ankney 1996; Nelson and Oetting 1998; Nieman et al. 2000). However, abundance and distribution are typically less understood and documented. Knowledge of abundance and distribution of Canada geese and any changes in them is important to managers when setting appropriate harvest regulations, in terms of maintaining Canada goose populations and hunter satisfaction. Because goose hunting and harvest regulations can be contentious (e.g., Miller 1998), information about goose abundance and distribution is necessary in helping to set seasons or harvest quotas. If, for example, reduction of a population via hunter harvest is the desired objective, increasing season length or bag limits in areas with relatively high densities is more likely to be successful in meeting the objective than changing season parameters in relatively low density areas.

Changes in abundance and distribution may indicate alterations in habitats that can negatively or positively affect goose populations. Additionally, changes in abundance and distribution of Canada geese may affect other

waterfowl or bird populations, for example, by competing for various resources (e.g., food). Habitat conservation programs or mitigation for habitat loss can be more effectively and efficiently delivered with an assessment of important areas to various populations. Finally, changes in abundance or distribution of Canada geese may result in increases in nuisance complaints. Understanding these changes may assist management agencies in acquiring and distributing resources to help alleviate problems in those areas.

Due to the establishment of local populations and increases in migrant populations, changes in abundance and distribution of wintering Canada geese along the Platte River system may have occurred since 1960. Thus, the objective of this study was to examine possible changes in abundance and distribution and to identify important river stretches of wintering Canada geese along the Platte Rivers of Nebraska from 1960 to 2000.

Methods

We used counts of Canada geese obtained from the Mid-Winter Survey (MWS). The Mid-Winter Survey is conducted annually by state and federal agency personnel to assess waterfowl distributions and habitat use and index some populations (Blohm 1989). The MWS is typically conducted in the first week of January using both aerial and ground surveys, with the same routes being covered since 1960 (Blohm 1989).

The entire length of the Platte river system and adjacent associated habitats (i.e., sandpits) in Nebraska were flown annually using high-winged aircraft. Aircraft flew at approximately 30 to 90 m above ground, and two observers were used. Numbers of Canada geese and other waterfowl were estimated visually. Ground counts also are conducted at various points along the Platte river system; however, counts from aerial surveys were used as the official count. Counts from aerial surveys were corroborated with ground counts when possible to determine discrepancies in counts, but formal methods to estimate detectability (sensu Williams et al. 2002) were not conducted.

For analyses, we divided the Platte river system into four identifiable main sections: (1) North Platte—from the Wyoming line to the Tri-County Diversion Canal east of the city of North Platte (Fig. 1), and (2) the South Platte—from the Colorado line to the Tri-County Diversion Canal (Fig. 1). The Platte River was subdivided into two main sections: (3) Central—the Platte River from the Tri-County Diversion Canal to Central City, NE (Fig. 2), and (4) East—the Platte River from Central City to the confluence with

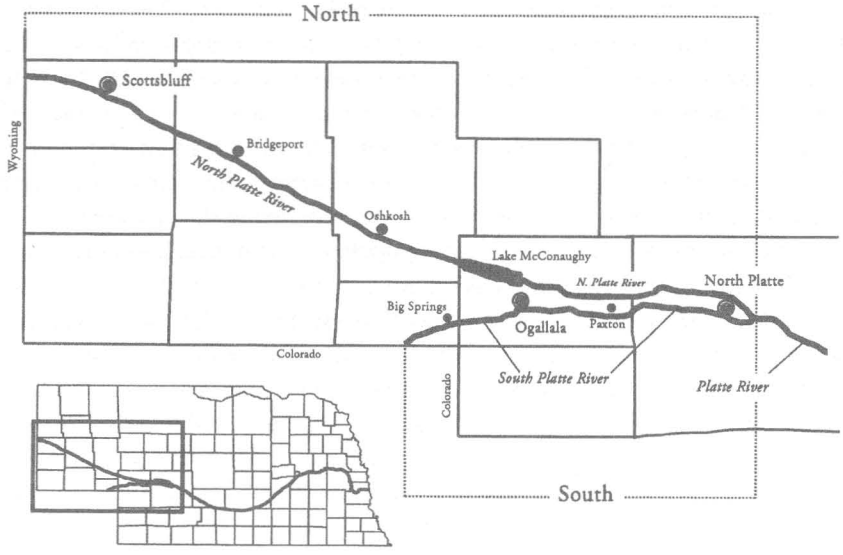

Figure 1. Location of the North and South Platte rivers in Nebraska and delineation of rivers into North and South sections for analysis of abundance and distribution of wintering Canada geese, 1960-2000.

the Missouri River) (Fig. 2). The North and South Platte are distinct rivers in Nebraska. Our division of the Platte River at Central City is near the boundary between the Big Bend reach and the eastern portion of the Platte River (Krapu et al. 1982). The East is the remainder of the Platte River and includes the confluences with the Loup and Elkhorn rivers.

The main river sections were then further divided into subsections at consistent and recognizable points (e.g., highway bridges) on the main sections. On the North Platte River, counts of Canada geese at Clear Creek Wildlife Management Area and Lake McConaughy were included in totals for the Lewellen-Kingsley Dam subsection, and counts for Cody Park in North Platte were included for the Paxton-Tri-County Diversion Canal subsection. Counts made at Grandpa's Steakhouse sandpit near Kearney were included in the Kearney-Gibbon subsection of the Central Platte River. Other counts made at adjacent ($\leq$ 3.2 km) areas along other subsections also were included in totals for those subsections.

Because we could not distinguish distinct time periods to separate counts of Canada geese based on biological or management (e.g., hunting

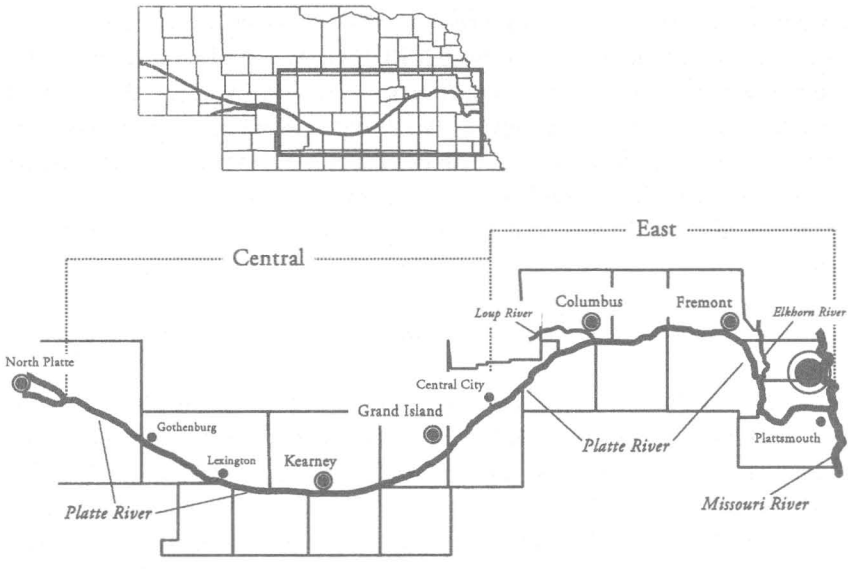

Figure 2. Location of the Platte River in Nebraska and delineation of the river into Central and East sections for analysis of abundance and distribution of wintering Canada geese, 1960-2000.

seasons) criteria, we arbitrarily divided counts into four time periods, hereafter decades: 1960-69, 1970-79, 1980-89, and 1990-2000. Further, this equalized sample sizes and made analyses and interpretation of data less complex.

Data were log-transformed [$\log_{10}(x + 1)$] to account for zeros in counts and to normalize distribution (Zar 1984). Because the aerial portion was not conducted along portions of the Central and the entire East section in 1998, data from 1998 were not included in analyses. However, data collected in 1998 were included in presentation of means for those sections and subsections where it was conducted. Analysis of variance (PROC GLM, SAS Institute 1989) was used to detect differences in numbers of wintering Canada geese between main river sections (North, South, Central, and East) and the four time periods. We used least-squares means (LSMEANS, SAS Institute 1989) for pairwise comparisons among combinations of rivers and decades. To examine changes in distribution of geese over the four decades, we divided the count of geese for each main section by the total number of Canada geese counted in all sections. We detected differences in mean

proportion of Canada geese wintering in each section and decade and in their interaction using analysis of variance (PROC GLM, SAS Institute 1989). We did not test main effects of river section or decade, as we knew there would be differences in the percentage of wintering Canada geese between river sections and no differences in decades (mean percentage for each decade would equal 1.0). Thus, neither would provide additional explanatory information with regard to possible changes in distribution of Canada geese over time.

Results

We found differences in mean abundance of wintering Canada geese among river sections ($P \leq 0.001$) and decades ($P \leq 0.001$). Abundance of wintering Canada geese was similar ($P = 0.52$) during 1960-69 and 1970-79. There also was a significant ($P = 0.002$) river by decade interaction due to no change or decrease in abundance of Canada geese in the South and East Platte from 1960-69 to 1979-79. During 1960-69 the order of river sections, from largest number of wintering Canada geese to smallest, was North-South-Central-East, whereas in 1970-79 it was North-Central-South-East (Table 1). For all decades, more ($P < 0.001$) Canada geese wintered along the North Platte River than any other river segment (Table 1). During 1960-69 there were similar ($P = 0.14$) numbers of Canada geese along the South, Central, and East sections. However, during 1970-79 and 1980-89, the Central section wintered more ($P = 0.02$) Canada geese than either the South or East sections. In 1990-2000 the Central and South Platte sections wintered similar ($P = 0.96$) numbers of Canada geese, but both had greater ($P < 0.001$) numbers of geese than the East section.

Distribution of wintering Canada geese along the Platte River system in Nebraska appears to have changed since the 1960s (Table 1). During 1960-69 the North Platte River held an average of 87% of all Canada geese along the Platte River system in Nebraska, but during 1990-2000 the mean dropped ($P < 0.002$) to 60% (Table 1). Conversely, the mean percentage of wintering Canada geese in the Central section of the Platte increased ($P < 0.005$) from 4% in 1960-69 to 28% during 1990-2000 (Table 1). Both the South and East sections held similar ($P > 0.05$) proportions of wintering Canada geese during the four decades.

The Lisco-Oshkosh subsection was the most important for wintering Canada geese along the North Platte River during 1960-2000, followed by the Lewellen-Kingsley Dam subsection (Table 2). The Hershey-Tri-County

TABLE 1

MEAN COUNTS, STANDARD ERROR (SE), AND PERCENTAGE OF TOTAL WINTERING CANADA GEESE ALONG THE PLATTE RIVER IN NEBRASKA

River Section[a]	Time period											
	1960-69			1970-79			1980-89			1990-2000		
	x	SE	%	*x*	SE	%	*x*	SE	%	*x*	SE	%
North Platte	640.4	115.3	87.0	1,225.5	209.2	83.2	1,636.7	342.6	68.3	5,575.6	833.7	57.2
South Platte	99.8	74.5	7.9	19.3	12.3	<1.0	153.3	61.9	4.9	1,245.9	312.5	10.0
Central	39.9	16.9	4.2	358.4	142.7	15.8	1,513.6	532.4	26.1	4,065.6	1,117.9	30.7
East	9.2	3.8	<1.0	1.3	0.9	<1.0	23.4	9.1	<1.0	239.5	67.7	2.1

[a] North Platte—North Platte River from the Wyoming line to the Tri-County Diversion Canal east of North Platte; South Platte—South Platte River from the Colorado line to the Tri-County Diversion Canal; Central—Platte River from the Tri-County Diversion Canal to Central City; East—Platte River from Central City to the confluence with the Missouri River.

TABLE 2

MEAN COUNTS AND STANDARD ERROR (SE) OF THE NUMBER OF WINTERING CANADA GEESE ALONG THE NORTH PLATTE RIVER, 1960-2000

Subsection	*x*	SE
Wyoming-Scottsbluff	1,652	683.1
Scottsbluff-Bayard	771	293.7
Bayard-Bridgeport	631	254.8
Bridgeport-Broadwater	1,262	593.3
Broadwater-Lisco	737	126.7
Lisco-Oshkosh	8,312	1,371.8
Oshkosh-Lewellen	867	165.0
Lewellen-Kingsley Dam	4,959	787.3
Kingsley Dam-Paxton	155	44.3
Paxton-TCD Canal	1,149	276.7

TABLE 3

MEAN COUNTS AND STANDARD ERROR (SE) OF THE NUMBER OF WINTERING CANADA GEESE ALONG THE SOUTH PLATTE RIVER, 1960-2000

Subsection	*x*	SE
Colorado line-Ogallala	470	178.5
Ogallala-Paxton	598	316.0
Paxton-Sutherland	19	10.6
Sutherland-Hershey	64	21.7
Hershey-Tri-County Diversion Canal	852	281.4

Diversion Canal subsection had the largest mean number of wintering Canada geese for the South Platte River (Table 3). For the Central and East sections, the Kearney-Gibbon and the Gothenburg-Lexington subsections had the largest numbers of wintering Canada geese (Table 4).

TABLE 4

MEAN COUNTS AND STANDARD ERROR (SE) OF THE NUMBER OF WINTERING CANADA GEESE ALONG OF THE CENTRAL AND EAST SECTIONS OF THE PLATTE RIVER, 1960-2000

Main section and Subsection	x	SE
Central		
Tri-County Diversion Canal-Gothenburg	118	98.6
Gothenburg-Lexington	1,576	604.1
Lexington-Elm Creek	789	406.8
Elm Creek-Kearney	723	288.1
Kearney-Gibbon	4,950	1,469.7
Gibbon-Alda	251	166.2
Alda-Central City	688	297.7
East		
Central City-Clarks	21	12.3
Clarks-Columbus	3	1.4
Columbus-North Bend	6	4.1
North Bend-Fremont	46	26.0
Fremont-Linoma Beach	281	95.6
Linoma Beach-Plattsmouth	53	26.6

Discussion and Conclusions

A number of factors may bias counts obtained from the MWS (Eggeman and Johnson 1989; Heusmann 1999). Additionally, annual variations (e.g., weather) make comparisons among states and years tenuous (Eggeman and Johnson 1989). To reduce bias, attempts were made to standardize survey methodology (e.g., through routes flown, limiting the number of observers) in Nebraska. Further, significant efforts have been made to conduct the MWS within a one-week time period, which reduces the possibility of waterfowl movement within and between states and areas.

Despite its potential shortcomings, we believe one of the strengths of the MWS is its unique, long-term database that allows a coarse though

reliable examination of changes in abundance and distribution of waterfowl populations. Evaluation of the MWS using transect surveys found that counts from the MWS were similar to those obtained from transect surveys (Conroy et al. 1988). Thus, for this analysis, we believe the changes in goose abundance and distribution we detected were reflective of actual population phenomena.

The number of Canada geese wintering along the Platte rivers has increased since the 1960s. Programs to establish breeding populations of Canada geese in Nebraska along the North Platte River, the Sandhills region of north-central Nebraska, and the Salt Valley Lakes region near Lincoln have been successful (Gabig 1986). Additionally, since 1960, establishment and proliferation of resident breeding populations of geese in other states have occurred, and increases in migrant Central Flyway Canada goose populations have generally increased since 1960 (Gabig 2000; Kruse and Sharp 2002). Finally, good breeding habitat conditions in prairie Canada and North and South Dakota have led to a 10% annual increase in the Western Prairie and Great Plains populations of Canada geese, which comprise the primary wintering populations using the Platte River (US Fish and Wildlife Service 2002; Vrtiska et al. in press). Collectively, these factors have led to the increase of wintering Canada geese we observed along the Platte River system.

The North Platte River has traditionally wintered more Canada geese than has other portions of the Platte River (Nebraska Game and Parks Commission, unpublished data). Our analysis found that this has not changed in 40 years, but other areas along the Platte are currently wintering a higher proportion of Canada geese. In particular, substantially increased numbers of Canada geese use the region between Gibbon and the Tri-County Diversion Canal discharge near North Platte . Increases in wintering populations of Canada geese also are evident along the East section.

A major factor in the increase in Canada geese in the Central and East sections is the increase in the number of sandpit lakes during the study period. Sandpits provide deepwater habitat that does not freeze as early as shallower wetland habitats, and most sandpits provide refuge for geese from hunting. Most sandpits still are used in active mining operations or are associated with housing developments after mining operations cease. With nearby agricultural fields that provide food resources, these habitats provide high-quality areas for wintering Canada geese. Additionally, protection and conservation of lands for sandhill cranes (*Grus canadensis*) along the Central Platte also created refuges for Canada geese. Canada geese use these areas until frozen and then shift to the deeper waters of the sandpit lakes.

Currently, knowledge about the wintering ecology of Canada geese in the Platte River system is limited. Increased understanding is needed to better identify critical habitat needs in order to provide adequate conservation, management, and restoration programs. With past and future demands on Platte River water (Krapu et al. 1985), conserving habitat needed by wintering Canada geese along the Platte River system will be important to maintain populations.

Another effect of increasing Canada goose populations along the Platte River, particularly in the Big Bend reach, is the potential impact to other species, most notably sandhill cranes. More than 70% of the midcontinent population of sandhill cranes stage along the central Platte River valley in spring (Tacha et al. 1992). Concurrent with the increases of wintering Canada geese in the Central section has been a shift in the distribution of sandhill cranes to the same general area (Faanes and LeValley 1993). Both Canada geese and sandhill cranes depend on waste grain to meet their energy requirements and to accumulate lipids for reproduction (Krapu et al. 1985; Wheeler et al. 1998). Consumption of waste grain by Canada geese during fall and winter may decrease the amount available for sandhill cranes during spring, potentially reducing their reproductive capability (Krapu et al. in press). Research examining waste grain availability and possible competition between Canada geese and sandhill cranes would assist in management decisions to provide adequate amounts of food resources for both species.

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