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FACTORS INFLUENCING WETLAND USE BY CANADA GEESE

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Abstract: Seasonal and semi-permanent wetlands in eastern South Dakota were surveyed in 1995 and 1996 to identify habitat characteristics influencing wetland use by Canada geese (*Branta canadensis maxima*). Position of a wetland within the landscape and its area were important landscape-scale features influencing wetland use by geese. Our delineation of potential Canada goose habitat using a wetland geographic information system indicated that distribution and area of semi-permanent wetlands likely limit Canada goose occurrence in regions outside the Prairie Coteau. Periodicity in hydrologic cycles within landscapes also may influence goose use of wetlands in eastern South Dakota.

Key Words: Canada goose, discriminant function analysis, eastern South Dakota, GIS, landscapes, wetlands

INTRODUCTION

During the early to middle 1800s, giant Canada geese (*Branta canadensis maxima* L.) commonly nested throughout most of the Great Plains region (Hanson 1965). By 1900, giant Canada geese had disappeared from much of their former breeding range (Lee 1987). A few flocks survived as remnant populations on private game farms, national wildlife refuges, and state wildlife management areas throughout the Great Plains region (Nelson 1963, Lee 1987). Habitat destruction, excessive hunting, and egg gathering were the main factors contributing to the decline of this subspecies (Hanson 1965, Lee 1987). During restoration efforts in South Dakota, 10,800 Canada geese were released (1967–94) in 25 counties across the state (South Dakota Department of Game, Fish and Parks unpubl. data).

Despite a considerable increase in numbers of giant Canada geese (Caithamer and Dubovsky 1996, Solberg 1996) following restoration, information on their use of breeding and brood-rearing habitat is lacking. Restoration efforts in the Dakotas have generally been concentrated in areas where water is available on a more permanent basis. Extended dry periods can limit or reduce breeding and subsequent pioneering unless suitable wetlands are available (Lee et al. 1984). Important Canada goose breeding and brood-rearing habitat features include availability of foraging sites (Zicus 1981, Lee et al. 1984, Bruggink et al. 1994), wetland size (Bultsma 1976, Hilley 1976, Kaminski and Prince 1977), and availability of nest sites (Bultsma 1976, Hilley 1976, Cooper 1978, Lee et al. 1984). The purpose of this study was to determine habitat characteristics related to Canada goose use of seasonal and semi-permanent wetlands. These characteristics were then incorporated into a geographic information system (GIS) to model potential Canada goose habitat throughout eastern South Dakota.

STUDY AREA

The study was conducted in 6 physiographic regions of eastern South Dakota (Johnson et al. 1995) that

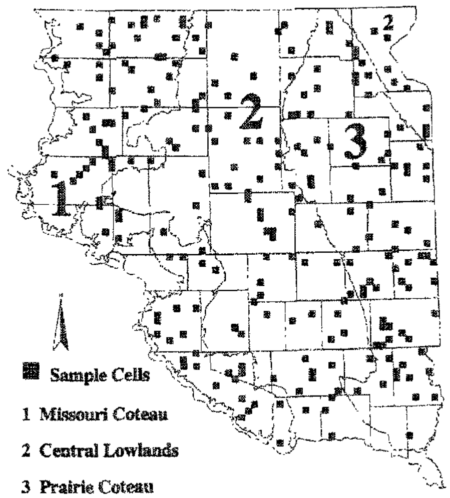

Figure 1. Distribution of 25.9 km² (10 mi²) cells across 3 domains used to determine goose use of seasonal and semi-permanent wetlands in eastern South Dakota, 1995 and 1996.

were modified into 3 domains (Figure 1) encompassing areas with similar wetland characteristics (Kantrud et al. 1989). The Prairie Coteau is characterized by an abundance of semi-permanent and permanent wetlands. The Central Lowlands is nearly flat with an abundance of seasonal and temporary wetlands. The Missouri Coteau has numerous seasonal wetlands in the northeast and fluviatile wetlands throughout the south and west. Allocation of total surface area in eastern South Dakota across domains is 28.7% in Prairie Coteau, 44.3% in Central Lowlands, and 27.0% in Missouri Coteau. In eastern South Dakota, 334,699 seasonal wetlands covering 224,004 ha and 24,485 natural, semi-permanent wetlands covering 173,010 ha were available for use by geese (Johnson 1995).

Native vegetation throughout eastern South Dakota is tall-grass/mixed-grass prairie (Westin and Malo 1978). Trautman (1982) provided a detailed description of land use across our domains. Land ownership is predominantly private interspersed with state-owned game production areas and federally owned waterfowl production areas.

METHODS

Sampling Methods

Sample Cells. A grid of 25.9 km² (10 mi²) cells was overlayed on a GIS layer constructed from National Wetland Inventory data for eastern South Dakota (Johnson 1995). Cell size was selected to maximize between-cell variability in the number and area of seasonal and semi-permanent wetlands within cells (Stoms 1992). The center of a wetland was used to assign wetlands that fell in multiple cells to a particular cell. Median values of the frequency distributions for wetland densities (110 wetlands) and areas (124 ha) were used to classify cells within domains into 4 strata: stratum 1 cells were low density and area, stratum 2 cells were low density and high area, stratum 3 cells were high density and low area, and stratum 4 cells were high density and area. Cells in each stratum within domains were numbered sequentially. Randomly selected cells (n = 216) were allocated equally across strata within domains in 1995 and 1996 (Figure 1). In 1996, an additional 7 cells from stratum 4 were randomly selected from each domain to ensure an adequate sample of semi-permanent wetlands.

Sample Wetlands. Two seasonal and 2 semi-permanent wetlands were surveyed within each cell. Wetlands that were sorted by area within cells were systematically selected using a random starting point to ensure that all sizes were surveyed. Additional wetlands were selected in the initial sample for each cell to replace wetlands found to be ineligible for inclusion in the study or for which access was denied. Wetlands that were dry, farmed, burned, or mowed were considered ineligible. Wetlands were surveyed after landowners were contacted to obtain permission to work in wetlands located on private lands.

Field Methods

Vegetation Sampling Within Wetlands. Vegetated wetland area was estimated visually using a modification of the Daubenmire scale in which the entire wetland was treated as a single quadrat (Bailey and Poulton 1968). Class intervals describing the percentage of vegetated area within wetlands were defined as 1) <1%, 2) 1–5%, 3) 6–25%, 4) 26–50%, 5) 51–75%, 6) 76–95%, and 7) >95%. Pattern of emergent vegetation was recorded using the 4 cover type classifications of Stewart and Kantrud (1971). Grazing intensity within the wetland was visually estimated as lightly, moderately, or heavily grazed.

Vegetation Sampling Surrounding Wetlands. Grazing intensity on wetland shorelines that were not cropped was recorded. We estimated grazing intensity on non-cropped shorelines by visual inspection of residual vegetation and the current year's growth (Kirsch 1969). Non-cropped shorelines that ranged from idled (i.e., <1%) to heavily grazed (i.e., >95%) were recorded using the same 7 class intervals that were used to estimate percent vegetated wetland area. Land use surrounding wetlands was classified as cropland, grassland, or mixed.

Canada Goose Counts. Wetland surveys were conducted from 5 May–10 July 1995 and 1996. The perimeter of each wetland was traversed after we had walked a zig-zag pattern within the wetland to ensure that all geese present were detected (Hammond 1969). Wetlands were classified as used by geese if we observed paired adults, active nests, or goslings. We surveyed wetlands once to obtain a large sample (n = 832) over an extensive geographic region rather than survey a small number of localized wetlands multiple times (Meentemeyer 1989). Wetlands that were surveyed from mid-June to early July were included in analyses to specifically include brood-rearing habitat in our predictive models.

Canada Goose Nest Sites. The number of potential Canada goose nest sites was recorded during 1996 wetland surveys. Potential nest sites for geese were defined as artificial nest structures, peninsulas or islands, muskrat (*Ondatra zibethicus* L.) houses, and spoil piles. Class intervals used to estimate the number of muskrat houses within wetlands were 1) 0, 2) 1, 3) 2–5, 4) 6–10, and 5) >10.

Canada Goose Release Sites. Canada goose banding records for South Dakota were obtained from the U. S. Geological Survey, Bird Banding Laboratory. Records were sorted by year for transported (Status 2) and hand-reared (Status 4) geese (i.e., restored Canada geese) that were banded and released by South Dakota Department of Game, Fish and Parks. Latitude and longitude from selected records were used to plot approximate release sites in eastern South Dakota from 1977 to 1984 and from 1985 to 1994.

Analytical Methods

Density and area of wetlands for each of 4 water regimes [temporary, seasonal, semi-permanent, permanent (Stewart and Kantrud 1971)] were calculated for each cell using GIS. Area (ha) and shoreline length (m) of sample wetlands also were calculated. Density and area of wetlands for each water regime, wetland area, and shoreline length of sample wetlands were log-transformed to approximate normality. Class interval mid-points were used to analyze categorical data. The 9 variables shown in Table 1 were used in analyses after eliminating total area of wetlands for each water regime, grazing intensity within the wetland, wetland perimeter measures, and cover type classifications from the data set to reduce problems associated with collinearity ($r > 0.5$).

Stepwise discriminant function analysis (Wilkinson 1990) was used to produce a linear combination of variables that best classified wetlands according to whether they were used or unused by Canada geese. Two separate stepwise discriminant functions were calculated to identify variables related to goose use of wetlands. Each of 9 variables was included in the first analysis to identify variables that separated used and unused wetlands. Only landscape variables (i.e., domain, wetland area, and wetland densities) encoded into the wetland GIS were included in the second discriminant function analysis. Separate analyses enabled us to use the landscape discriminant function to depict potential goose habitat throughout eastern South Dakota using GIS. We classified wetlands as used or unused according to the largest value of the classification functions (Wilkinson 1990:367–390). Jackknife classification rates (Wilkinson 1990) were used as a method of cross-validating our ability to predict potential Canada goose habitat. Seasonal wetlands were excluded from all analyses because geese were recorded on <1% of seasonal wetlands surveyed.

We used t-tests with Bonferroni corrected probabilities (Wilkinson 1990) to determine whether the availability of potential nest sites (e.g., muskrat houses) differed between used and unused wetlands.

Table 1. Means (± SE) of landscape and vegetative variables for used and unused wetlands by giant Canada geese in eastern South Dakota, 1995 and 1996.

	Used (n = 34)		Unused (n = 377)	
Variable	$\bar{x}$	SE	$\bar{x}$	SE
Domain	2.8	0.1	1.9	0.1
Temporary Density[a]	71.1	10.6	97.9	3.7
Seasonal Density[a]	56.0	7.9	83.8	3.9
Semi-permanent Density[a]	16.4	3.4	14.3	1.2
Permanent Density[a]	1.9	0.2	2.1	0.1
Wetland Area (ha)	24.7	8.9	11.7	2.8
% Vegetated Wetland Area	31.0	4.8	56.1	1.7
Land Use	2.3	0.1	2.0	0.1
Shoreline Grazing Intensity	28.2	6.5	32.1	2.1

[a] Number of wetlands within 25.9 km^2 cells (10 mi^2).

RESULTS

Giant Canada geese occurred on 34 (8.3%) of 411 semi-permanent wetlands surveyed (Table 1). The first discriminant function identified the position of a wetland within the landscape (i.e., domain), wetland area, and percent vegetated wetland area as important in separating semi-permanent wetlands that were used by Canada geese (Wilks' Lambda = 0.82; F = 29.55; df = 3,1,409; $p < 0.001$) (Table 2). Vegetated wetland area explained the least variation and was the only vegetative variable retained. The greatest differences between used and unused wetlands were associated with landscape variables, indicating that the position of a wetland within the landscape and its area may be

Table 2. Classification functions for discriminating between wetlands used and unused by giant Canada geese in eastern South Dakota, 1995 and 1996. The first function contains vegetative and large-scale landscape variables to discriminate between used and unused wetlands. The second function that contains only landscape variables was used in a wetland geographic information system to predict potential goose habitat throughout eastern South Dakota.

Variable	Classification Function Coefficients		% Variation Explained
	Used	Unused	
Full Discriminant Function[1]			
Constant	−12.56	−7.64	
Domain	5.37	3.77	45.0%
Wetland Area	3.15	2.08	34.6%
% Vegetated Wetland Area	0.04	0.06	11.5%
% Correctly Classified	82%	79%	
Jackknifed Classification Rate	79%	79%	
Landscape Discriminant Function[2]			
Constant	−8.11	−3.83	
Domain	4.89	3.25	47.0%
Wetland Area	1.68	0.51	36.0%
% Correctly Classified	88%	75%	
Jackknifed Classification Rate	82%	75%	

[1] Wilks' Lambda = 0.82, $F = 29.55$, df = 3,1,409, $p < 0.001$.
[2] Wilks' Lambda = 0.85, $F = 36.38$, df = 2,1,409, $p < 0.001$.

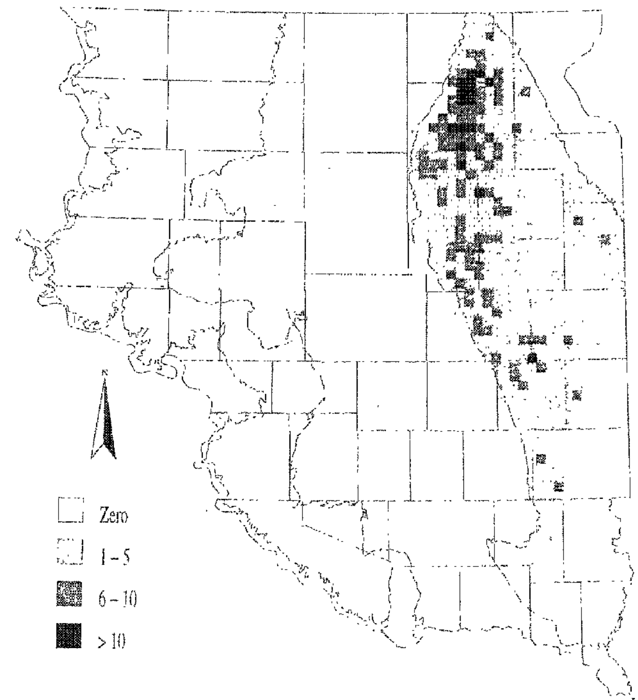

Figure 2. Distribution of semi-permanent wetlands in eastern South Dakota that were delineated as suitable breeding and brood-rearing habitat for Canada geese. Degree of shading indicates the number of suitable wetlands within 25.9 km^2 (10 mi^2) cells. The landscape discriminant function indicated that wetlands suitable for Canada geese occurred almost exclusively within the Prairie Coteau domain (see Figure 1).

the most important features influencing wetland use by geese.

The discriminant function analyzing landscape variables identified domain and wetland area as significant (Wilks' Lambda = 0.85; $F = 36.38$; df = 2,1,409; $p < 0.001$) (Table 2). Domain contributed most to the discriminant function (Table 2), with used wetlands occurring more within the Prairie Coteau than other domains (Table 1). Wetland area also contributed to the discriminant function (Table 2); average area of used wetlands ($\bar{x} = 24.7$ ha) was larger (Table 1) than the area of unused wetlands ($\bar{x} = 11.7$ ha). Variables excluded from the discriminant function were wetland densities of each water regime and year. The discriminant function correctly classified 88% of used and 75% of unused wetlands by Canada geese (Table 2). Jackknife procedures correctly classified 82% of wetlands that were used and 75% of wetlands that were not used by Canada geese.

The landscape discriminant function was used in the GIS to classify all semi-permanent wetlands in eastern South Dakota as used or not used by Canada geese. Number of semi-permanent wetlands that were classified as expected to be used by geese were summarized by cell into 4 classes 1) 0, 2) 1–5, 3) 6–10, and 4) >10 used wetlands (Figure 2). Results indicated that wetlands suitable for Canada geese occurred almost exclusively on the Prairie Coteau (Figure 2). The minimum area of semi-permanent wetlands in which geese occurred was 0.70 ha. Numbers of semi-permanent wetlands ≥0.70 ha throughout eastern South Dakota also were summarized by cell into classes using GIS. Wetlands ≥0.70 ha were largely within the Prairie Coteau but may include isolated areas of the Central Lowlands and Missouri Coteau (Figure 3).

During 1977–84, restoration efforts occurred in the middle zone of the Prairie Coteau and northern zone of the Missouri Coteau (Figure 4). Restoration efforts from 1985 to 1994 have occurred in the southern zone of the Prairie Coteau and scattered zones of the Central Lowlands and Missouri Coteau (Figure 4). Distribution of wetlands ≥0.70 ha more closely depicted areas selected as release sites compared to distribution of wetlands delineated using the landscape discriminant function.

Fifty percent of wetlands used by Canada geese in 1996 had ≥ 1 muskrat house. Number of muskrat houses was greater ($t = 2.435$, df = 418, $p = 0.029$)

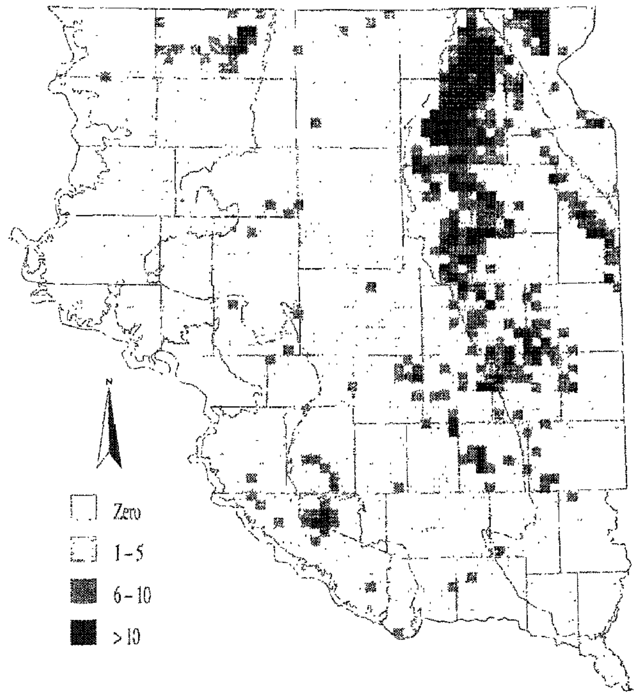

Figure 3. Distribution of semi-permanent wetlands in eastern South Dakota that were delineated as potential breeding and brood-rearing habitat for Canada geese. Degree of shading indicates the number of suitable wetlands within 25.9 km² (10 mi²) cells. Distribution of wetlands ≥0.70 ha indicated that most wetlands suitable for geese were within the Prairie Coteau domain but may include isolated areas of the Central Lowlands and Missouri Coteau domains (see Figure 1).

in used ($\bar{x}$ = 2.4) than unused ($\bar{x}$ = 1.4) wetlands. Flooded spoil piles were present in an additional 21% of used wetlands that did not have muskrat houses present. Fewer alternative nest sites were available (t = 7.552, df = 418, $p < 0.001$) in used ($\bar{x}$ = 1.8) versus unused ($\bar{x}$ = 2.0) wetlands.

DISCUSSION

Landscape Features Influencing Goose Use of Wetlands

The majority of wetlands that we delineated as potential goose habitat were concentrated within the Prairie Coteau (Figure 2) due to the large number of semi-permanent wetlands. Canada geese were not released into the northern Prairie Coteau because remnant wild populations have always occurred in this region (Nelson 1963). Banding records indicated that geese were released into isolated semi-permanent wetlands west of the Prairie Coteau (Figure 4). Our delineation of potential goose habitat may be conservative (Figure 2) when compared to the distribution of minimum area wetlands (≥0.70 ha) on which geese occurred (Figure

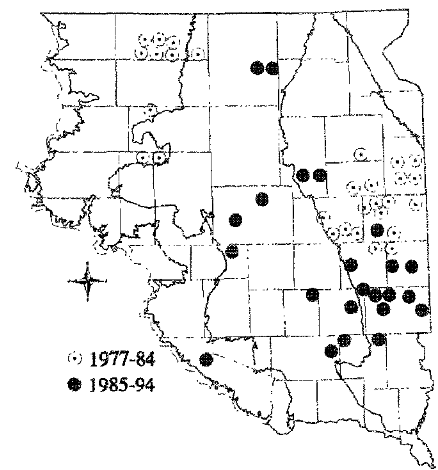

Figure 4. Release sites of transported (Status 2) and hand-reared (Status 4) Canada geese during restoration in eastern South Dakota, 1965–1994.

3). Our surveys indicated that geese are not widespread west of the Prairie Coteau despite restoration efforts from 1977 to 1994 (Figure 4).

Mean area of wetlands used by giant Canada geese in eastern South Dakota ($\bar{x}$ = 24.7 ha) was twice as large as unused wetlands ($\bar{x}$ = 11.7 ha). Semi-permanent wetlands that we classified as potential goose habitat may be equally important for breeding and brood-rearing Canada geese. Less numerous permanent wetlands (i.e., glacial lakes) (Johnson 1995), which were excluded from this study, likely provide additional nesting and brood-rearing habitats throughout the region (Nigus and Dinsmore 1980). In their analysis of 18 habitat components correlated with waterfowl pair numbers, Leschisin et al. (1992) documented greater pair use on wetlands with larger surface areas. Similarly, Kaminski and Prince (1977) reported that giant Canada geese in Michigan used wetlands >2 ha, and use exceeded availability for wetlands >25 ha. Although Brown and Dinsmore (1986) concluded that Canada geese in Iowa used smaller wetlands located in wetland complexes, our analysis indicated that wetland isolation did not influence goose use of semi-permanent wetlands in South Dakota, as the densities of seasonal and semi-permanent wetlands within cells were excluded from our discriminant function.

Vegetative Features Influencing Goose Use of Wetlands

Our goal of investigating large-scale landscape features in relation to potential goose habitat required visits to many sites that were geographically dispersed, with a reduced level of vegetative sampling at individual wetlands. The emphasis on large-scale spatial patterns decreased our ability to predict specific vegetation preferences of geese within specific wetlands (Meentemeyer 1989). However, our relatively high jackknifed classification rates using the landscape discriminant function (82% and 75%) (Table 2), when compared to classification rates of the function containing landscape and vegetation variables (79% and 79%), indicated that the inclusion of vegetation measures did not enhance our ability to predict potential goose habitat.

Results of our study indicated that geese used wetlands with relatively little emergent vegetation (e.g., *Typha* spp., *Scirpus* spp.) (Table 1). Goose use of sparsely vegetated wetlands may have reflected timing of season in which surveys were conducted. Less densely vegetated wetlands that were used by geese during brood-rearing may have provided open water habitat for predator avoidance (Lee et al. 1984).

Even though availability of nest sites was significant ($P \leq 0.05$) for used and unused wetlands, we did not include nest sites in our model because data were only available for 1 year. Our results support the findings of Kaminski and Prince (1977), Cooper (1978), and Ogilvie (1978) regarding the importance of muskrat houses for breeding giant Canada geese. Although grazing intensity was not used to discriminate between used and unused wetlands in our study, Eberhardt et al. (1989) found that grazed shoreline pastures were important foraging habitats for Canada goose broods in Washington. Similarly, Zicus (1981) concluded that habitats surrounding wetlands influenced available foraging sites used by family groups of Canada geese in Wisconsin.

Spatial and Temporal Variation in Goose Use of Wetlands

The Prairie Coteau has the highest density of wetlands that demonstrate long-term predictability in annual hydrologic cycles. Canada geese that have been released in the Central Lowlands and Missouri Coteau use large and isolated semi-permanent wetlands during years of favorable water conditions. However, highly variable wet-dry cycles (Winter 1989) make wetland conditions inherently unpredictable at restoration sites outside the Prairie Coteau. Although semi-permanent wetlands rarely dry completely, sparsely vegetated wetlands that regenerate with dense vegetation during dry periods may be unattractive to Canada geese. Juxtaposition of semi-permanent wetlands on the Prairie Coteau may enable geese to move short distances to wetlands in which favorable vegetative conditions occur; however, geese outside the Prairie Coteau may have to move long distances before locating a suitable wetland. Unfortunately, little is known concerning seasonal movement patterns and pair site fidelity in the Great Plains that might enable geese to colonize new areas when isolated wetlands throughout the Central Lowlands and the Missouri Coteau are unsuitable. Although such information for the Great Plains is lacking, periodicity in hydrologic cycles within landscapes (Euliss and Mushet 1996) is likely a major factor influencing goose use of wetlands in eastern South Dakota.

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