Wetland Use by Wintering Geese in the Gulf Coast Plains and Rice Prairie Region of Texas, USA

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We studied wetland habitat use by wintering geese in the Coastal Plains and Rice Prairie Regions of Texas during 1991-92 and 1992-93. White-fronted Geese were most abundant on lacustrine littoral aquatic-bed floating vascular ($\bar{x}$=2.10/ha) and unconsolidated shore organic ($\bar{x}$=1.55/ha) wetlands. White geese (Snow and Ross') were most abundant on estuarine intertidal aquatic-bed algal ($\bar{x}$=8.71/ha) wetlands. Canada Geese were most abundant on lacustrine littoral unconsolidated shore vegetated ($\bar{x}$= 1.81/ha) wetlands. Geese used 16 of the 82 wetland types in the study area. Management of both open-water and vegetated wetlands is necessary to effectively influence the distribution and abundance of wintering geese.

Key words: Canada Geese, Greater White-fronted Geese, Lesser Snow Geese, Ross' Geese, Texas, Wetland Use, Wintering

Agricultural crops on wintering and staging areas have contributed to larger and less variable fat reserves of Greater White-fronted Geese *Anser albifrons* and Lesser Snow Geese *Chen caerulescens caerulescens*, resulting in increased survival and productivity (Alisauskas & Ankney 1992; Krapu *et al.* 1995). Increased food supply on wintering areas has allowed unprecedented growth in most populations of North American geese (Ankney 1996; Batt 1997). For example, Snow Geese increased 300% from 1969 to 1994 (Batt 1997). White geese (approximately 90% Snow and 10% Ross' *Chen rossii* Geese [Harpole *et al.* 1994]) number > 3.2 million, White-fronted Geese number 665,000, and Canada Geese *Branta canadensis* number 205,000 in coastal Texas, USA (Anderson *et al.* 1998).

Innovative harvest and habitat manipulations are needed to address the issues associated with the increased population of Midcontinent Snow Geese in North America (Ankney 1996). However, a greater understanding of the habitats used by geese and distribution of species among wetland types on their wintering grounds is necessary to achieve these goals (Hobaugh *et al.* 1989; Ballard & Tacha 1995). While it is clear that wetlands provide important roosting and feeding areas for geese, little research has addressed the types and attributes of wetlands most important to geese (Bateman *et al.* 1988; Miller *et al.* 1997). Our objective was to document the most important wetland types and characteristics for wintering geese in the coastal plains and rice prairies of Texas.

Study area

The study area consisted of 24 coastal Texas counties (excluding most of the urban [eastern] portions of Harris and Galveston counties) covering 5,504,389 ha (Anderson *et al.* 1996; 1998). The study area was comprised of two initiative areas defined by the North American Waterfowl Plan (Anderson *et al.* 1998). The Texas Mid-coast (TMC) Initiative Area occurred from the Nueces River north to Galveston Bay and as far inland as rice production occurs (**Figure 1**). The Laguna Madre (LM) Initiative Area extended from the Nueces River south to the Rio Grande River. The study area is dominated by coastal marsh and rice fields in the TMC and sandy plains and coastal prairie in the LM (Anderson *et al.* 1998). The primary agricultural crops in the study area were sorghum, cotton, rice, and corn (Texas Agricultural Statistics Service 1992).

Average annual precipitation ranges from 133 cm in the TMC (Larkin & Bomar 1983) to 55 cm in the LM (National Fibers Information Center 1987). The TMC coastal zone is primarily located in the Louisianian Estuarine and Marine Province (Cowardin *et al.* 1979), characterised by extensive marshes and well-developed barrier islands. The LM area is primarily located in the West Indian Estuarine and Marine Province (Cowardin *et al.* 1979). The LM area is characterised by a shoreline of predominantly low-lying limestone with calcareous sands and marls. About 250,000 ha of palustrine wetlands (Cowardin *et al.* 1979), which is the most numerous wetland system, occur in the study area (Muehl *et al.* 1994). The most abundant emergent vegetative dominance types in palustrine wetlands include *Typha domingensis, Phragmites australis, Spartina spartinae, Zizaniopsis milacea*, and *Scirpus californicus* (Anderson & Tacha 1998). Detailed descriptions of the initiative areas are provided in Anderson *et al.* (1996; 1998).

Methods

Stratification

We divided the LM (Cotton, Range, and Produce) and the TMC (Rice Prairie, Coastal, and Other Crop) area into three strata (Anderson *et al.* 1996; 1998), based on major physiographic regions and land use practices. The Other Crop, Cotton, and Produce strata consisted primarily of row crops, but rangeland and urban areas also occurred. The Range stratum was primarily native grassland and brush. The Rice Prairie stratum was dominated by rice production, but other crops, pasture,

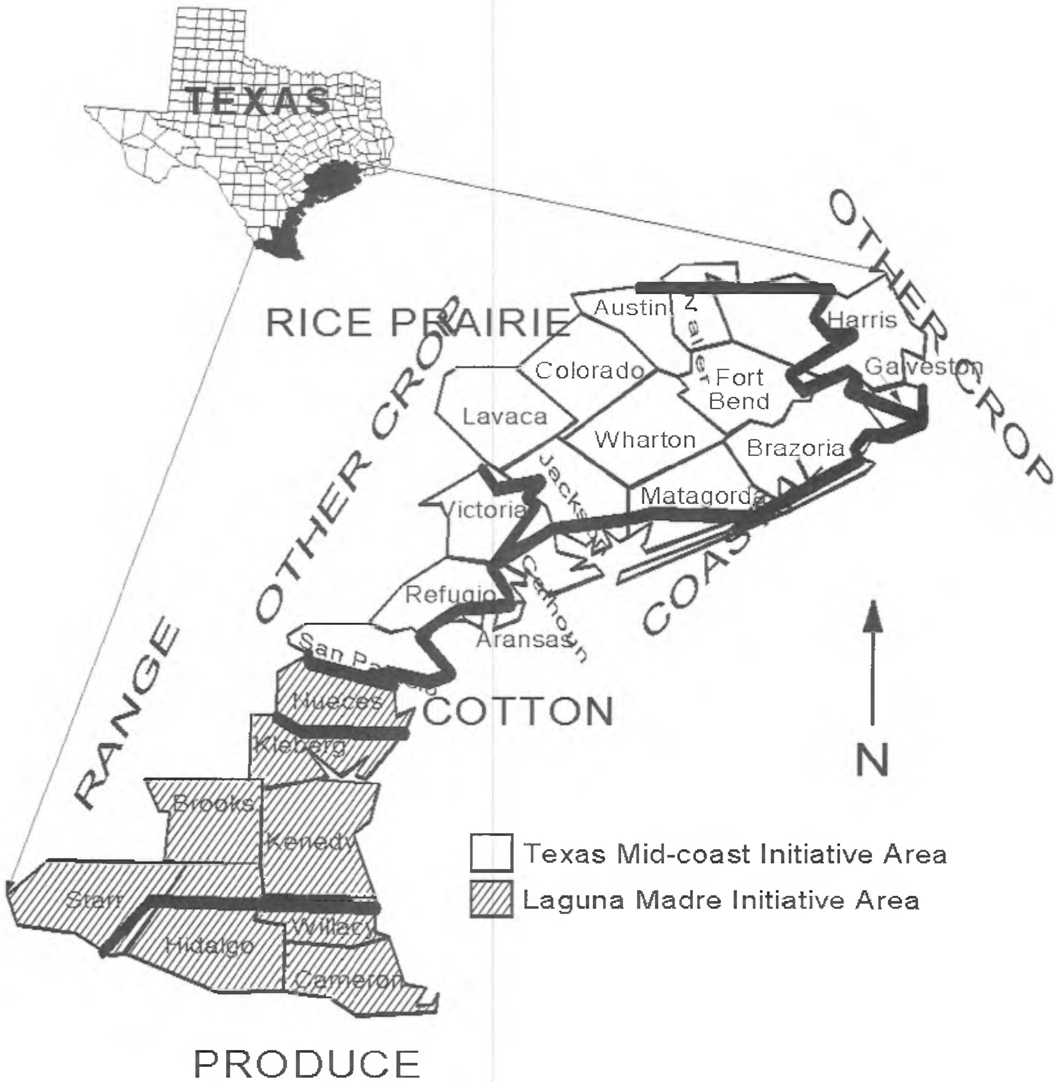

Figure 1. Location of Texas Mid-coast and Laguna Madre Initiative areas and strata boundaries for goose habitat use of wetland types in the Coastal Plains and Rice Prairie regions of Texas during November and January 1991-92 and 1992-93.

and woods also were present. The Coastal stratum was a thin strip along the coast that was dominated by coastal salt marsh and fresh water prairie wetlands.

In 1991-92, we used map coordinates to randomly select 290, 64.75-ha (one-quarter section) plots in proportion to strata size in the TMC (Rice Prairie n = 201, Coastal n = 25, Other Crop n = 64) area and 220 plots in the LM (Cotton n = 25, Range n = 111, Produce n = 86) area (Anderson *et al.* 1996; 1998). Each plot, whether a wetland was present or absent, had an equal chance of being selected. This was done, so waterbird densities and wetland area from surveyed plots could be extrapolated to the entire study area to estimate population sizes for each bird species (Anderson *et al.* 1998) and to determine number and area of wetlands in the study area (Muehl *et al.* 1994; Anderson & Tacha 1998). The number of plots with wetlands ranged from 40% in the Other Crop stratum to 91% in the Coastal stratum. In 1992-93, we increased the number and reallocated the distribution of plots among strata to decrease variance of population estimates (Kish 1965) based on birds counted in January 1992 (Anderson *et al.* 1996; 1998). Because most birds were located in the Coastal stratum, we added more plots to this area even though it was the smallest stratum (Anderson *et al.* 1996). We located 409 plots (Cotton n = 136, Range n = 46, Produce n = 227) in the LM and 600 plots (Rice Prairie n = 241, Coastal n = 273, Other Crop n = 86) in the TMC during 1992-93.

After plots were randomly selected within strata, we obtained access permission or, if access was denied, replaced the plot with another randomly selected plot (Anderson *et al.* 1996; 1998). Wildlife refuges with extensive salt marsh habitat, large bays, or island habitats were not included in the study area, because these areas are not conducive to ground surveys (Anderson *et al.* 1998). However, aerial surveys of these habitats indicated that only 3.2% of geese in the study area occurred in the areas that were not surveyed from the ground (Anderson *et al.* 1998). Additionally, other areas of salt marsh habitat were surveyed and therefore all wetland types in the region were included in the study (Muehl *et al.* 1994). Similar stratified random sample surveys of one-quarter section plots have been conducted for waterfowl in other regions of North America (Stewart & Kantrud 1972; Brewster *et al.* 1976; Heitmeyer 1980).

Goose observations

We surveyed plots once during each two-week survey period in late November and early January 1991-92 and 1992-93 to count geese and classify wetlands following Anderson *et al.* (1996; 1998). We counted all geese by species (except Snow and Ross' Geese which occurred in large mixed flocks and were designated white geese) and recorded wetland type where geese occurred. Only the portion of a wetland that occurred within a plot was surveyed. The extent and number of wetlands on a plot varied among count periods (Anderson *et al.* 1996). Counts took from ten to 60 minutes per plot to complete and were conducted throughout the day. Counts were not conducted on plots where waterfowl hunting was known to have occurred during that day (Anderson 1994). Adjacent plots were counted on the same day to minimise double-counting of geese. Anderson *et al.* (1998) provides an overview of advantages and disadvantages of using ground counts of plots to count waterbirds and assess habitat. By counting geese throughout the day on a large sample of wetlands, we were able to get an overall assessment of habitat use for each species (Anderson *et al.* 1996).

Wetland classification

We classified all wetlands on plots according to Cowardin *et al.* (1979). We recorded system, subsystem, class, and subclass for each wetland and subsequently referred to these as wetland types. Wetland systems found on the study plots included estuarine, riverine, lacustrine, and palustrine. Wetlands were classified within two weeks of conducting goose surveys.

We also recorded six modifiers (ie wetland alteration, water regime, soil type, size, presence or absence of aquatic-bed vegetation, and vegetation pattern) in addition to wetland type for each wetland. We placed wetland alterations into one of three categories: farmed, manmade, or natural. All wetlands with evidence of agricultural activity were placed in the farmed wetland category (Cowardin *et al.* 1979). Farmed wetlands were primarily rice fields, but other fields with sheet water also were included in this category. Wetlands were considered manmade if they were not farmed, but had the excavated, impounded, diked, or artificial categories of Cowardin *et al.* (1979).

We classified water regimes as permanent, seasonal, or temporary. Eight water regimes of Cowardin *et al.* (1979) were included in the permanently flooded category: subtidal, irregularly exposed, regularly flooded, permanently flooded, intermittently exposed, semi-permanently flooded, permanently flooded-tidal, and semi-permanently flooded-tidal. Three water regimes were included in the seasonally flooded category: seasonally flooded, artificially flooded, and seasonally flooded-tidal. Five water regimes were included in the temporarily flooded category: irregularly flooded, saturated, temporarily flooded, intermittently flooded, and temporarily flooded-tidal.

We determined soil type (mineral or organic) in the field (Soil Conservation Service 1975:66; Cowardin *et al.* 1979; Muehl *et al.* 1994). Wetland size was determined following techniques of Millar (1973), and placed into one of three categories: <0.5, ≥0.5 but <5, and ≥5 ha. We recorded wetland size during each count period as the area of a wetland covered by water.

Aquatic-bed vegetation (algae, rooted vascular, and floating vascular species) was recorded as present or absent. Distribution pattern of emergent, scrub-shrub, and forested vegetation was recorded for each wetland as cover type one (<5% open water), two (5-94% emergent vegetation interspersed with open water), three (≥5% open water with exterior rings of emergent vegetation), or four (≥95% open water) (Stewart & Kantrud 1971).

Data analyses

We combined data across initiative areas, count periods, and years for analyses (Anderson *et al.* 1996). We assumed that observations of the same wetland basin in successive count periods and years were independent (Haukos & Smith 1993; Anderson & Tacha 1999) because wetlands were so dynamic (ie dried or flooded; Muehl *et al.* 1994; Anderson & Tacha 1998), count periods were two months apart (Anderson *et al.* 1996), and the number of geese on wetlands and in the study area varied between count periods (Anderson

Table 1. Mean densities ($\bar{x}$) and standard errors (SE) of wintering White-fronted, white (Snow and Ross' Geese), and Canada Geese by wetland type in the Coastal Plains and Rice Prairie region of Texas, USA, November and January 1991-92 and 1992-93.

	Density (Number/ha)[a]					
	White-fronted Geese[b]		White Geese[c]		Canada Geese[d]	
Wetland Type (Cowardin *et al.* 1979)	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Estuarine subtidal unconsolidated bottom mud	0.01b	0.01			0.01c	0.01
Estuarine subtidal aquatic-bed algal			4.41b	1.63		
Estuarine intertidal aquatic-bed algal	0.57b	0.56	8.71a	8.64	1.21b	1.21
Estuarine intertidal aquatic-bed rooted vascular	0.17b	0.17	1.49bc	1.46	0.09c	0.09
Estuarine intertidal unconsolidated shore mud	0.18b	0.18	1.15bc	1.14	0.07c	0.05
Estuarine intertidal emergent persistent	0.02b	0.02	1.00c	0.99	0.03c	0.03
Lacustrine littoral unconsolidated bottom mud	0.76ab	0.75	8.42ab	8.32	0.18c	0.15
Lacustrine littoral aquatic-bed rooted vascular	1.18ab	0.59				
Lacustrine littoral aquatic-bed floating vascular	2.10a	2.09				
Lacustrine littoral unconsolidated shore organic	1.55a	0.97	7.49ab	7.00	0.20b	0.19
Lacustrine littoral unconsolidated shore vegetated					1.81a	1.68
Palustrine aquatic-bed rooted vascular			0.98c	0.97	0.05c	0.05
Palustrine unconsolidated shore organic	0.01b	0.01	0.08c	0.08		
Palustrine unconsolidated shore vegetated	0.14b	0.14	0.01c	0.01	0.27b	0.27
Palustrine emergent persistent	0.52b	0.52	3.28b	3.28	0.09c	0.04
Palustrine scrub-shrub broad-leaved deciduous			0.86c	0.78		

[a] The same letter in a column indicates no differences amoung density ranks ($P > 0.10$). Ranks have been back-transformed to original means and SEs for presention.
[b] Density ranks ($F = 7.73$; 11, 1985 df; $P<0.001$) varied among wetland types used by White-fronted Geese.
[c] Density ranks ($F = 5.38$; 11, 1942 df; $P<0.001$) varied among wetland types used by white geese.
[d] Density ranks ($F = 4.32$; 10, 1298 df; $P<0.001$) varied among wetland types used by Canada Geese.

et al. 1998). Wetlands served as the experimental unit; therefore, wetlands without any geese were included in the analysis if that species occurred on at least one wetland of that type (Anderson *et al.* 1996). Wetland types in which geese never occurred were excluded from analyses because we assumed these wetland types did not provide suitable habitat for a species (Anderson *et al.* 1996). The number and area of wetlands by type, based on the same study plots used in this study, are found in Muehl *et al.* (1994).

We calculated density for each species on each wetland as number of geese/ha of water. All densities were rank-transformed, because (based on visual inspection) data were not normally distributed (Conover & Iman 1981; Potvin & Roff 1993). Density ranks were dependent variables in one-way analyses of variance; the independent variables were wetland types (Anderson 1994; Anderson *et al.* 1996). We separated means using Scheffe's procedure (SAS Institute Inc. 1990) and $\alpha = 0.10$. Rank densities were back-transformed for presentation.

Results

We counted 2,440 Canada Geese (n = 30 flocks), 57,984 white geese (n = 55), and 12,613 White-fronted Geese (n = 48 flocks) on surveyed wetlands. Geese used 16 wetland types (five lacustrine, six estuarine, five palustrine) in the study area (**Table 1**). White-fronted and Canada Geese were most abundant in lacustrine littoral wetlands, whereas white geese were most abundant in estuarine intertidal and lacustrine littoral wetlands (**Table 1**).

Farmed wetlands were more important than other manmade or natural wetlands for White-fronted Geese and Canada Geese (**Table 2**). Highest densities for all goose species were on seasonally flooded wetlands and wetlands >5 ha in size. White goose rank densities were higher on mineral soils, whereas Canada Goose rank densities were greater on organic soils. White goose densities were higher on wetlands with aquatic-bed vegetation than wetlands without aquatic-bed vegetation. White-fronted Geese and white geese density ranks were highest on densely-vegetated wetlands.

Discussion

Geese used 16 of the 82 (20%) wetland types that occurred in the study area (Muehl *et al.* 1994; Anderson *et al.* 1996). The important wetland types used by geese included most of the abundant wetland types, but also included some rare types (eg estuarine subtidal aquatic-bed algal and lacustrine littoral unconsolidated shore vegetated) (Muehl *et al.* 1994). It is evident that all wetland types used are important, because some with moderate density ranks (ie palustrine emergent persistent and estuarine intertidal emergent persistent) account for a large area and therefore support a large number of geese. Geese generally fed in vegetated wetlands (eg emergent persistent and scrub-shrub) and roosted in open wetland (eg unconsolidated shore and unconsolidated bottom) types (Anderson 1994). Indeed, both open-water and emergent wetlands are important to wintering geese.

Some of the lacustrine littoral unconsolidated shore vegetated and organic wetlands had been developed specifically for geese as artificial roost ponds. Roost ponds were first developed in the rice prairies in the 1950s and 1960s

Table 2. Mean densities ($\bar{x}$) and standard errors (SE) of wintering White-fronted, white (Snow and Ross' Geese), and Canada Geese by wetland characteristic in the Coastal Plains and Rice Prairie region of Texas, USA, November and January 1991-92 and 1992-93.

		Density (Number/ha)[a]					
		White-fronted Geese		White Geese		Canada Geese	
Wetland Modifier	Parameter	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Alteration[b]	Farmed	1.20a	1.20	3.25a	1.76	0.78a	0.06
	Natural	0.42b	0.37	2.17a	1.30	0.09b	0.06
	Manmade	0.16b	0.45	2.45a	1.52	0.07b	0.04
Water Regime[c]	Seasonally Flooded	1.21a	1.20	5.31a	2.12	0.18a	0.17
	Permanently Flooded	0.46b	0.46	2.00b	1.31	0.01b	0.01
	Temporarily Flooded	0.29b	0.29	0.06c	0.05	0.01b	0.01
Soil[d]	Mineral	1.55a	1.00	5.72a	3.91	0.04b	0.02
	Organic	0.01a	0.01	0.41b	0.21	0.10a	0.06
Size[e]	Large (≥5 ha)	0.80a	0.79	3.36a	1.09	0.11a	0.04
	Medium (≥0.5 ha but <5 ha)	0.32b	0.20	0.89b	0.48	0.13b	0.09
	Small (<0.5 ha)	0.69b	0.35	3.16b	3.16	0.01b	0.01
Aquatic-bed Vegetation[f]	Present	1.43a	1.41	6.01a	3.54	0.07a	0.05
	Absent	0.32a	0.29	0.27b	0.18	0.05a	0.05
Vegetative Pattern[g]	1 (<5% open water)	0.73a	0.66	5.27a	2.48	0.11a	0.08
	2 (Vegetation/open water mix)	0.67ab	0.38	2.17ab	0.98	0.15a	0.09
	3 (exterior vegetative rings)	0.00c	0.00	2.81ab	2.61	0.03a	0.02
	4 (≥95% open water)	0.66bc	0.39	0.34b	0.33	0.04a	0.04

[a] The same letter in a column for a wetland modifier indicates no difference among density ranks ($P>0.10$). Ranks have been back-transformed to original means and SEs for presentation.
[b] Density ranks varied among alteration modifiers for White-fronted (F=6.44; 2, 1994 df; P=0.002) and Canada (F=10.74; 2, 1306 df; P<0.001), but not for white (P=0.660) Geese.
[c] Density ranks varied among water regime modifiers for White-fronted (F=25.56; 2, 1994 df; P<0.001), white (F=15.77; 2, 1951 df; P<0.001), and Canada (F=5.73; 2, 1306 df; P=0.003) Geese.
[d] Density ranks varied between soil modifiers for white (F=5.17; 1, 1952 df; P=0.023) and Canada (F=5.08; 1, 1307 df; P= 0.024), but not for White-fronted (P=0.206) Geese.
[e] Density ranks varied among wetland size modifiers for White-fronted (F=37.24; 2, 1994 df; P<0.001), white (F=53.47; 2, 1951 df; P<0.001), and Canada (F=9.60; 2, 1306 df; P<0.001) Geese.
[f] Density ranks varied between aquatic-bed vegetation modifiers for white (F=4.61; 1, 1952 df; P=0.032), but not for Canada (P=0.894) or White-fronted (P=0.595) Geese.
[g] Density ranks varied among vegetative pattern modifiers for White-fronted (F=10.99; 3, 1993 df; P<0.001) and white (F= 6.83; 3, 1950 df; P<0.001), but not for Canada (P=0.118) Geese.

and have since increased in popularity (Lobpries 1990). Their main purpose has been to keep geese in localised areas to provide more opportunities for waterfowl hunting (Hobaugh *et al.* 1989). There are fewer roosts ponds within about 30 km of the coast. Therefore, in coastal areas, some of the estuarine open-water wetlands were important for roosting geese.

Natural and manmade wetlands were of lower value to geese than farmed wetlands. Historically, Snow Geese wintered almost exclusively in coastal marshes (McIlhenny 1932; Glazener 1946; Lynch *et al.* 1947), but gradually expanded their winter range north into the prairies as rice culture developed (Glazener 1946; Bateman *et al.* 1988). Shallow flooded rice stubble, which included some of the palustrine emergent persistent wetlands, were important in this study and others (Hobaugh 1984; Leslie & Chabreck 1984; Harpole *et al.* 1994). Because of the vast amount of rice fields (900,000 ha) in Texas, Louisiana, and Arkansas (Batt 1997) and moderate densities of geese, this wetland type is of great importance throughout the three states. Cultivated and natural foods available to geese in rice fields and other farmed wetlands have probably contributed to the increase in Snow Goose populations (Alisauskas *et al.* 1988; Robertson & Slack 1995; Batt 1997). Agriculture fields without wetlands also were important habitats for geese in this study, with about 50% of geese occurring on non-wetland habitats (Anderson 1994; Anderson *et al.* 1998).

Density ranks of geese were highest in seasonally flooded wetlands, probably as a result of increased nutrients available to waterfowl (Fredrickson & Taylor 1982; Anderson & Smith 1998). Seasonally flooded wetlands included many of the lacustrine littoral and palustrine emergent wetland types. Additionally, many of the important farmed wetlands were seasonally flooded which contributed to the high use of this water regime. Seasonally flooded wetlands are valuable to a variety of waterbird species due to high seed and invertebrate production (Fredrickson & Taylor 1982; Haukos & Smith 1993; Anderson *et al.* 1996; Anderson & Smith 1999).

Large wetlands ($\geq$ 5 ha) were most important for geese. Coastal salt marshes, rice fields, and lacustrine wetlands are generally large and often used by geese. Many of these wetlands also were densely vegetated, another favoured characteristic of wetlands used by geese, if vegetation is not too tall and robust (Anderson & Tacha 1998). Because geese are highly gregarious and often occur in mixed flocks on wintering grounds (Ballard & Tacha 1995; Gawlik & Slack 1996) they probably prefer larger wetlands for foraging and resting.

White-fronted Goose densities were greatest in lacustrine littoral aquatic-bed floating vascular wetlands, Canada Goose densities were greatest in lacustrine littoral unconsolidated shore vegetated wetlands, and white goose densities were greatest in estuarine intertidal aquatic-bed algal wetlands. Density ranks of geese varied drastically among species and wetland types. These differences in wetland use among species provide useful tools for management of individual goose populations and habitat quality in coastal Texas.

Wetland management and acquisition activities in coastal Texas should concentrate on wetlands that are important to White-fronted and Canada Geese. Lacustrine littoral unconsolidated shore vegetated and lacustrine littoral aquatic-bed floating vascular wetlands should be of primary importance because they provide quality habitat for these two species without attracting many Snow Geese.

Because Snow Geese often feed in some common wetland types in the area (Anderson 1994) and use a variety of wetland types, manipulation of habitats to decrease Snow Goose populations is difficult. It is doubtful that meaningful population control can be achieved through habitat manipulation alone. However, it may be beneficial to provide some of the lacustrine littoral wetlands, as roosting sites, in areas where roost ponds are rare (ie Other Crop stratum in TMC and all strata in LM) to increase opportunities for harvest of geese. An added benefit of providing more lacustrine littoral wetlands is that a diversity of other waterbird species in the area also rely on these wetland types (Anderson 1994; Anderson *et al.* 1996). Management plans with the goal of increasing less abundant goose populations or decreasing overabundant goose populations must consider the impacts on the entire waterbird community.

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