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HABITAT USE BY GEESE WINTERING IN SOUTHERN TEXAS

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ABSTRACT—Habitat use and activities of wintering Canada geese (*Branta canadensis*), lesser snow geese (*Chen c. caerulescens*), and greater white-fronted geese (*Anser albifrons frontinalis*) were studied in Refugio County, Texas during October through February 1990–1991 and 1991–1992. Contrasting rainfall during the two study seasons appeared to affect food availability, habitat use, and number of geese observed. Nearly 7 times more geese were recorded during the wet winter of 1991-1992 than during the dry winter of 1990–1991. Geese selectively used ($P < 0.10$) improved pasture during October through February 1990–1991; although geese exclusively used disced sorghum fields (69% of study area) until late November 1990, they shifted to improved pasture (3% of study area) during December through February. Sprouting vegetation was more available in disced sorghum fields during 1991–1992, when geese selectively used ($P < 0.10$) disced sorghum during both fall and winter. Disced sorghum was the most intensively used habitat during both winters. Percent of time spent feeding by geese did not differ ($P > 0.10$) among habitats; geese spent >60% of their diurnal time foraging in disced sorghum fields.

Resource use by geese wintering in Texas has primarily been studied in the rice-prairie region and coastal marshes of southeastern Texas (Hobaugh, 1984, 1985; Alisauskas et al., 1988; Hobaugh et al., 1989). Little information exists on habitat use by geese south of the rice-dominated prairies, and in the Coastal Bend area where cropland is dominated by cotton and grain sorghum (Glazener, 1946). Grain sorghum is the only high-energy agricultural food grown extensively throughout southern Texas. The Coastal Bend area of southern Texas has historically supported large numbers of geese in winter (C. R. Wilson, pers. comm.), but numbers have declined in recent years. This decline has coincided with changes in land-use practices in the Coastal Bend area to promote earlier planting of crops, particularly sorghum. This has resulted in more intensive cultivation during fall and winter to prepare fields for planting during late February and early March.

This study was part of a larger project to determine management methods of grain sorghum that would benefit wintering waterfowl in southern Texas (Ballard, 1993). Objectives of the work reported here were to: (1) quantify habitat use by 3 species of geese wintering in Refugio County, Texas, (2) determine changes in habitat use between fall and winter, and (3) delineate habitats that were important feeding areas for geese.

MATERIALS AND METHODS—Refugio County is in the Coastal Bend of southern Texas, approximately 60 km north of Corpus Christi. The terrain is coastal prairie intermingled with streams and bays, with little variation in elevation except on the western edge where it becomes gently rolling (Guckian, 1984). Climate is subtropical with an average annual rainfall of 95.5 cm; maximum monthly precipitation occurs in September. Average seasonal temperatures range from 28°C in summer to 14°C in winter. About 78% of the land is used for livestock grazing, and 19% is cropland, mainly grain sorghum and cotton.

Geese were studied at two locations in Refugio County during winter. The Austwell study area contained a 90-km survey route and was located on the east side of Refugio County between U.S. Highway 35 and the coast, and south of Tivoli to the northern border of Arkansas National Wildlife Refuge. Approximately 12,800 ha were observable from the route, of which 9,800 ha could be used by geese. Unusable habitats included urban areas, areas of timer, heavy brush, and cropland in the Conservation Reserve Program (CRP) where vegetation was tall and dense. A second 86-km survey route in south-central Refugio County (Bayside study area) was located east of the

town of Woodsboro to Mission Bay and south to the town of Bayside. Approximately 11,100 ha were observable from the route, of which 7,445 ha could be used by geese.

The Austwell route was surveyed on two nonconsecutive days every other week from October through February 1990–1991. Both routes were surveyed once each week during October through February 1991–1992. Routes were driven two times each survey day to include the first 3 h after sunrise and the last 3 h before sunset. Inventories of cropland throughout study areas were made before harvest to record field-type availability. Field sizes were obtained from the Refugio County Agriculture Stabilization and Conservation Service (ASCS). A flock was defined as any group of ≥1 goose separated by at least 50 m from any other group or individual and located together in a single habitat type. A group observed in two adjoining habitat types was considered as two separate flocks. Field type and condition, and number of each species of goose were recorded for each flock encountered. Ross' geese (*Chen rossii*) were not differentiated from snow geese. For each flock, we noted whether or not fields had vegetation.

Four habitat types of potential use to geese were identified (Table 1). The dominant habitat types were grain sorghum and cotton in 1990-1992. Both were disced immediately following harvest in mid-July. Fallow field included cropland not planted the previous spring, and included a variety of plant species. Improved pasture was land planted in ryegrass or clover and grazed by livestock. All observations of flocks were made in these four habitats.

Activities of geese were determined through observations of flocks along the survey routes. Percent of entire flock engaged in any of six behaviors, alert, comfort (preening, scratching, bathing, and stretching), feeding, locomotion, resting, and other (Frederick and Klaas, 1982), was estimated by scanning the flock with a 15–60× spotting scope.

Number of each goose species using each study area in each 2-week interval was estimated as the maximum number of a species observed in one survey during that 2-week period. Kolmogorov-Smirnov (K-S) tests (Conover, 1971) were used to determine if distributions of numbers of geese across fortnights were different from a uniform distribution. K-S tests were also used to compare differences in distributions of numbers of each species of goose between years.

Differences in use of habitats among species across seasons and within-species between seasons and years were tested using Chi-square analyses. Habitat selection or avoidance was determined using methods of Neu et al. (1974). The proportion of each species of goose observed in each habitat type was multiplied by the total number of flocks of that species observed. This gave an adjusted number of flocks based on proportion of birds and avoided the bias of differing flock sizes. One-way analysis of variance was used to analyze variation among habitats on arcsine-transformed activity data (SAS Inst., 1987). Habitat selection was tested with Bonferroni's inequality, a conservative approach to lack of independence (Neu et al., 1974). The alpha level was set at 0.10 rather than 0.05 as in other analyses to compensate for the relatively small sample sizes and large number of non-independent comparisons (Neu et al., 1974). Correlation analyses were used to examine the relationships among environmental variables and behaviors.

RESULTS—A total of 665 flocks containing an estimated 173,437 geese was observed; mean flock size was 261 (SE = 16). Although surveys began on 1 October both years, geese did not arrive on study areas until mid-October in both years (Figs. 1–3). Use was low and irregular on the Austwell study area in 1990–1991 (Fig. 1). A total of 69 flocks with a mean flock size of 121 (SE = 18) was observed during 1990–1991; an average of 306 geese was observed per survey. Goose use was higher on the Austwell study area during 1991–1992 (Fig. 2). A total of 233 flocks with a mean flock size of 265 (SE = 30) was observed; an average of 2,060 geese was observed per survey. The highest concentration of geese in either season was recorded on the Bayside study area during 1991–1992 when 363 flocks were observed with a mean flock size of 285 (SE = 22), and an average of 3,104 geese were observed per survey (Fig. 3).

White-fronted geese were most numerous through October, but then were less abundant than either Canada or snow geese through February (Figs. 1–3). Canada geese were most numerous, generally becoming abundant from late November until late January or early February. Distribution of numbers of snow geese varied the most between years and study areas ($P < 0.05$).

Distributions of numbers of both snow and white-fronted geese were not uniform (K-S tests, $P < 0.01$) over time during 1990–1991. Eighty-three percent of all snow geese observed in 1990–1991 were recorded in the last survey period in late February. However, 82% of all white-fronted geese were observed in the first two survey periods in 1990–1991. Numbers of Canada geese appeared uniformly distributed over the same survey period ($P > 0.05$). During October through February 1991–1992, numbers of white-fronted geese on the Austwell study area were not uniformly distributed ($P < 0.05$), with 98% observed in the first three surveys. Canada and snow goose

TABLE 1—Occurrence of three species of geese in four habitat types on two survey routes in Refugio County, Texas, October through February; 1990–1991 and 1991–1992. Values shown for each species are numbers of birds counted and numbers of flocks counted (parentheses for flocks show the proportion of the total number of flocks observed and the 90% family confidence limits).

Study area (year)/habitat type	Area		Canada goose		Snow goose		White-fronted goose	
	ha	Proportion	Birds	Flocks	Birds	Flocks	Birds	Flocks
Austwell (1990–1991)								
Disced sorghum	5,848	0.69	1,407	22 (0.46, 0.30–0.62)[1]	2,415	16 (0.07, 0.48–0.91)	1,823	18 (1.00)
Improved pasture	229	0.03	848	13 (0.28, 0.13–0.42)[2]	970	6 (0.28, 0.07–0.49)[2]	0	0 (0.00)
Fallow field	136	0.02	559	9 (0.18, 0.06–0.31)[2]	0	0 (0.00)	0	0 (0.00)
Disced cotton	2,263	0.27	246	4 (0.08, 0.00–0.17)[1]	80	1 (0.02, 0.00–0.09)[1]	0	0 (0.00)
Total	8,476	1.00	3,060	47 (1.00)[3]	3,465	23 (1.00)	1,823	18 (1.00)
Austwell (1991–1992)								
Disced sorghum	4,346	0.52	26,046	139 (0.98, 0.96–1.00)[2]	17,697	93 (0.75, 0.66–0.84)[2]	5,737	38 (0.96, 0.90–1.00)[2]
Improved pasture	135	0.02	135	1 (0.01, 0.00–0.02)	2,151	11 (0.09, 0.03–0.15)[2]	100	1 (0.02, 0.00–0.06)
Fallow field	118	0.01	291	2 (0.01, 0.00–0.03)	1,960	10 (0.08, 0.03–0.14)[2]	118	1 (0.02, 0.00–0.07)
Disced cotton	3,824	0.45	0	0 (0.00)	1,841	10 (0.08, 0.02–0.13)[1]	0	0 (0.00)
Total	8,423	1.00	26,472	141 (1.00)[3]	23,649	124 (1.00)	5,955	40 (1.00)[3]
Bayside (1991–1992)								
Disced sorghum	5,268	0.77	45,780	187 (0.83, 0.77–0.88)	30,257	141 (0.75, 0.68–0.82)	6,829	160 (0.89, 0.83–0.94)[2]
Improved pasture	158	0.02	5,896	24 (0.11, 0.06–0.15)[2]	6,781	32 (0.17, 0.11–0.23)[2]	524	12 (0.07, 0.03–0.11)[2]
Fallow field	158	0.02	2,724	11 (0.05, 0.02–0.08)	3,419	16 (0.08, 0.04–0.13)[2]	179	4 (0.02, 0.00–0.05)
Disced cotton	1,284	0.19	947	4 (0.02, 0.00–0.04)[1]	0	0 (0.00)	177	4 (0.02, 0.00–0.05)[1]
Total	6,868	1.00	55,347	226 (1.00)	40,457	189 (1.00)[3]	7,709	180 (1.00)

[1] Avoidance of the habitat type; observed number of flocks significantly fewer ($P < 0.10$) than expected (expected = total number of flocks × proportionate abundance of the habitat type).

[2] Preference of the habitat type; observed number of flocks significantly greater ($P < 0.10$) than expected.

[3] Because of rounding errors, the individual values do not sum to the total.

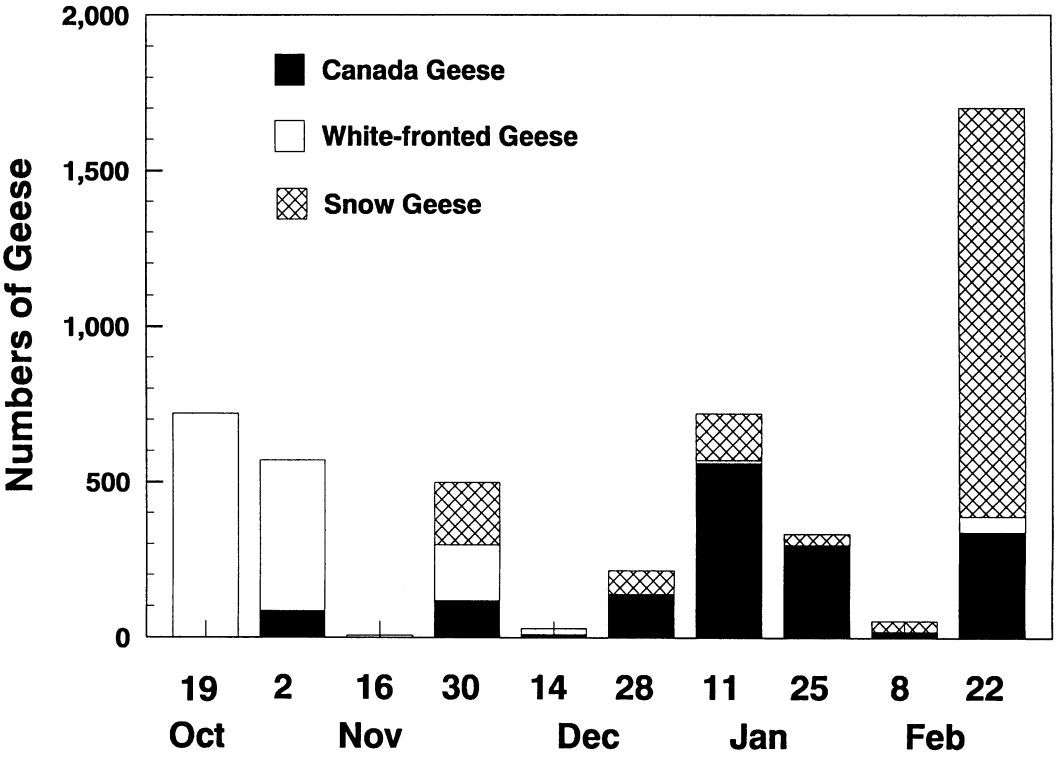

FIG. 1—Maximum numbers of three species of geese observed at the Austwell study area every 2 weeks during October through February 1990–1991 in Refugio County, Texas.

numbers were uniformly distributed ($P > 0.05$) on the Austwell study area in 1991–1992. All three species of geese were uniformly distributed ($P > 0.05$) over time on the Bayside study area in 1991–1992.

Distributions of numbers of snow geese using the Austwell study area differed ($P < 0.01$) between years due mainly to the high proportion observed in late February in 1990-91. Distributions of numbers of Canada geese also differed ($P < 0.05$) between years, with relatively higher numbers occurring late in the survey period in 1990-91. Distributions of numbers of white-fronted geese did not differ ($P > 0.05$) between years.

Food availability was related to differences in rainfall during the two winters. Rainfall after harvest in August through February 1990–1991 averaged 3.78 cm per month, or only 62% of the 30-year average for that same period. Dry conditions allowed farmers to cultivate fields throughout the fall and most fields had been cultivated four or five times by the time geese arrived. This intense cultivation buried any waste grain before goose arrival (Ballard, 1993). Lack of moisture compounded effects of cultivation in limiting forage growth. Mean post-harvest rainfall was 12.7 cm per month during August through February 1991–1992, or 208% of the 30-year average. Wet conditions reduced access of farmers to crop fields and diminished sorghum availability through moisture-related decay, but produced a flush of sprouting vegetation (forage) in disced sorghum fields.

More geese were observed in disced sorghum fields than any other habitat during both years (Table 1). Overall, 68% and 83% of all observed geese were in disced sorghum fields in 1990–1991 and 1991–1992, respectively. Geese were seen exclusively in disced sorghum fields in fall 1990, but by late November they were distributed more evenly among available habitats, except for white-fronted geese. However, disced sorghum fields continued to be most used throughout both fall and winter by all geese.

Canada geese used disced sorghum during 1990–1991 relatively more ($\chi^2 = 10.05, P = 0.002$) in fall than in winter, when they moved to im-

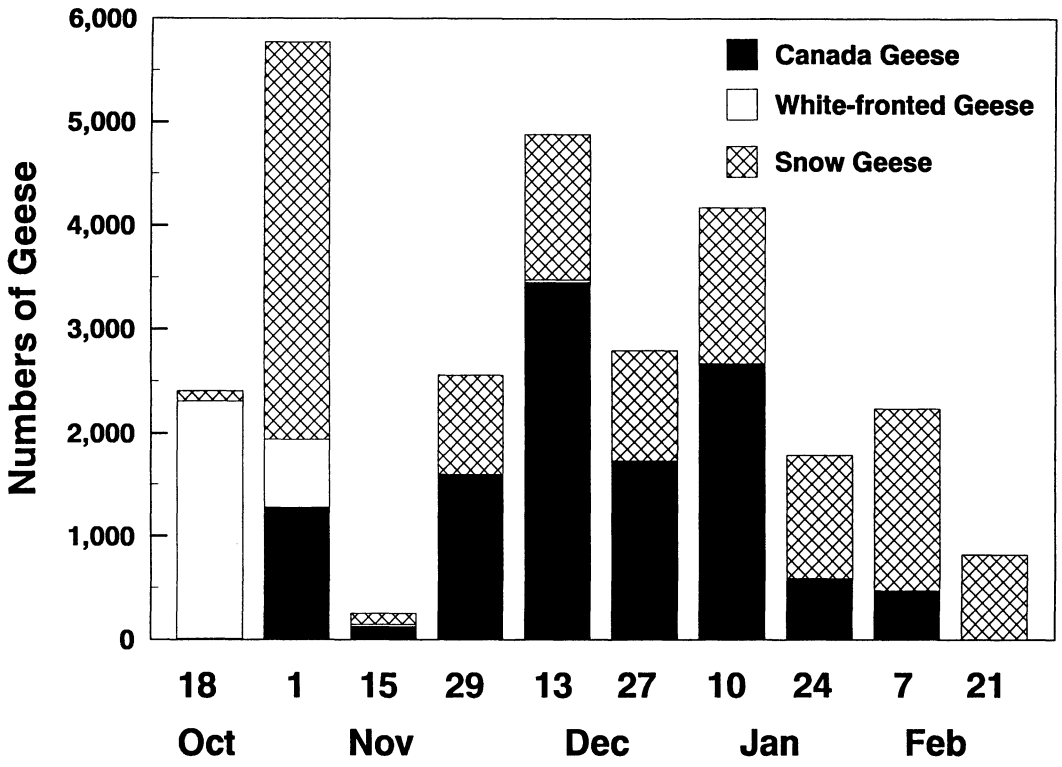

FIG. 2—Maximum numbers of three species of geese observed at the Austwell study area every 2 weeks during October through February 1991–1992 in Refugio County, Texas.

proved pasture and fallow fields. Seasonal use of disced sorghum by Canada geese did not differ during 1991-92. Snow geese used improved pasture more ($\chi^2 = 5.11$, $P = 0.009$) during fall than winter, and disced cotton more ($\chi^2 = 22.09$, $P = 0.030$) in winter than fall during 1991–1992. White-fronted geese used disced sorghum fields more ($\chi^2 = 4.41$, $P = 0.036$) in fall than in winter 1991–1992, but generally used sorghum fields heavily throughout fall and winter during both years.

Use of all habitats except disced cotton differed among species during both years (Table 2). Use of sorghum by snow geese was lower than white-fronted geese during 1990–1991 ($\chi^2 = 6.60$, $P = 0.010$), and lower than both white-fronted ($\chi^2 = 19.45$, $P < 0.001$) and Canada geese ($\chi^2 = 23.23$, $P < 0.001$) during 1991–1992. Use of sorghum by white-fronted geese was higher ($\chi^2 = 16.56$, $P < 0.001$) than Canada geese during 1990–1991, but not during 1991–1992 ($P = 0.670$).

Use of improved pasture (Table 2) by snow geese was higher than white-fronted geese in 1990–1991 ($\chi^2 = 5.52$, $P = 0.019$) and 1991–1992 ($\chi^2 = 8.41$, $P = 0.004$), and higher than Canada geese in 1991–1992 ($\chi^2 = 9.06$, $P = 0.003$). White-fronted geese improved pasture less ($\chi^2 = 6.20$, $P = 0.013$) than Canada geese during 1990–1991, but not during 1991–1992 ($P = 0.677$).

Canada geese used fallow fields (Table 2) more than snow geese ($\chi^2 = 5.06$, $P = 0.025$) or white-fronted geese ($\chi^2 = 4.00$, $P = 0.045$) during 1990–1991. However, in 1991-92 snow geese used fallow fields more than Canada geese ($\chi^2 = 8.18$, $P = 0.004$) or white-fronted geese ($\chi^2 = 8.58$, $P = 0.003$). Use of fallow field was not different ($P = 0.491$) between Canada and white-fronted geese during 1991–1992.

Use of sorghum fields by Canada geese differed ($\chi^2 = 80.82$, $P < 0.001$) between years on the Austwell study area, with higher sorghum use in 1991–1992 (99%) than in 1990–1991 (45%). Use of improved pasture by Canada geese also differed between years on the Austwell study area ($\chi^2 = 37.09$, $P < 0.001$), with higher use during 1990–1991 (28%) than in 1991–1992 (<1%). Use of disced cotton habitat was relatively low for all

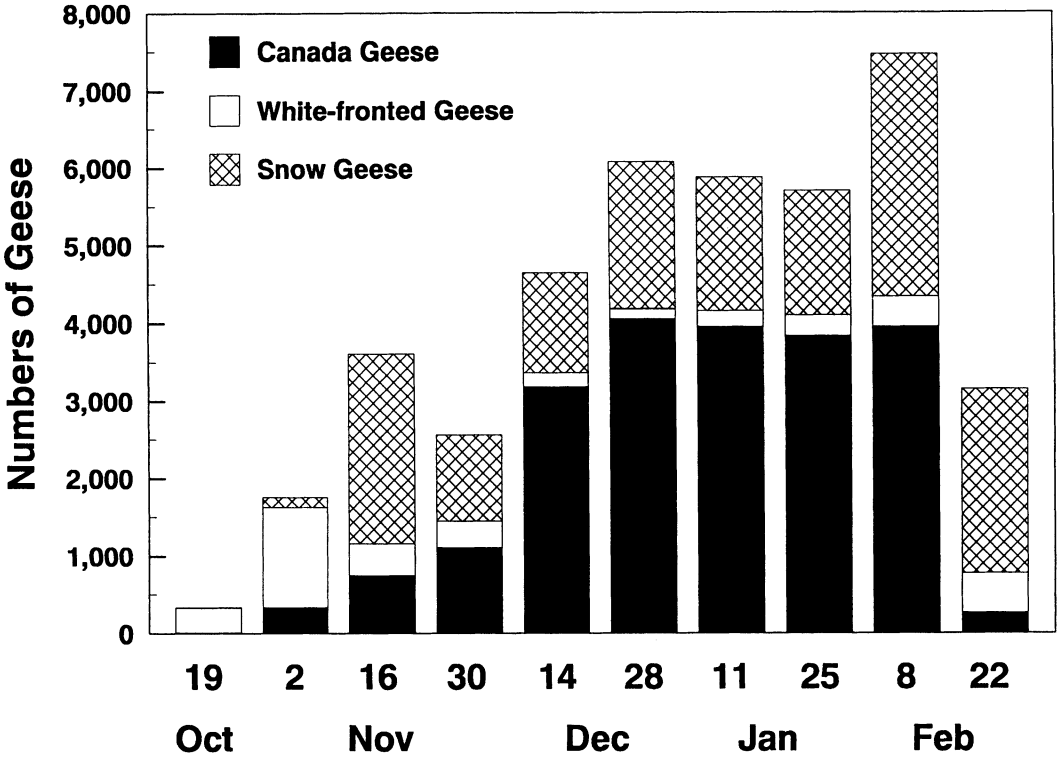

FIG. 3—Maximum numbers of three species of geese observed at the Bayside study area every 2 weeks during October through February 1991–1992 in Refugio County, Texas.

species, and no difference ($P > 0.14$) was observed for either year (Table 2).

Canada geese preferred sorghum on the Austwell study area in 1991–1992, but avoided it in 1990–1991 (Table 1). Preference for improved pasture by Canada geese was evident in 1990–1991 on the Austwell study area, and in 1991–1992 on the Bayside study area. Fallow field habitat was also preferred in 1990–1991. Canada geese underutilized disced cotton in both years.

There was no difference ($P > 0.10$) in use of disced sorghum or improved pasture between years by snow geese on the Austwell study area. Snow geese preferred improved pasture in both years and on both study areas (Table 1). Fallow field was preferred on both study areas in 1991–1992, as well as for disced sorghum on the Austwell study area in 1991–1992. Snow geese underutilized disced cotton during both years.

There was no difference ($P > 0.10$) in use of disced sorghum or improved pasture between years on the Austwell study area by white-fronted geese. White-fronted geese preferred disced sorghum in both years and on both study areas (Table 1). Improved pasture also was preferred on the Bayside study area during 1991–1992. White-fronted geese were not observed using fallow field or improved pasture in 1990–1991 on the Austwell study area. White-fronted geese underutilized disced cotton during both years.

Goose flocks preferred disced sorghum fields with green vegetation ($Z = 350$, $P < 0.001$). Eighty-eight percent of geese using disced sorghum were observed in fields that contained green vegetation (about 50% of sorghum fields).

Mean percentages ($\pm SE$) of geese observed in each activity from 522 flock observations over both years were: alert 17.8 ± 3.4, comfort 1.3 ± 0.5, feeding 73.9 ± 12.2, locomotion 3.0 ± 1.1, rest 3.6 ± 1.8, and other 0.4 ± 0.3. Variation in activities among habitat types was low. Percentage of geese observed feeding did not differ ($P > 0.05$) among habitats. Environmental variables (temperature, cloud cover, wind speed, wind direction, and precipitation) were not associated ($P > 0.05$) with arcsine transformed activity percentages.

TABLE 2—Percent habitat use compared among snow, Canada, and white-fronted geese in Refugio County, Texas, October through February 1990–1991 and 1991–1992.

Year/habitat	Percent use[1]			χ^2	P
	Snow goose	Canada goose	White-fronted goose		
1990–1991					
Disced sorghum	70	46	100	17.7	<0.001
Improved pasture	28	28	0	6.3	0.044
Fallow field	0	18	0	8.8	0.013
Disced cotton	2	8	0	1.9	0.394
1991–1992					
Disced sorghum	75	89	90	32.6	<0.001
Improved pasture	14	7	6	13.3	0.001
Fallow field	8	3	2	13.5	0.001
Disced cotton	3	1	2	3.9	0.143

[1] Number of flocks counted in each habitat, expressed as the percent of the total number of flocks counted. See Table 1 for numbers of flocks.

DISCUSSION—Food availability appears to be a primary factor controlling use of habitats by geese within Refugio County. In dry years, fields are repeatedly disced after harvest in July and early August, and most available sorghum is buried by the time geese arrive in October (Ballard, 1993). Forage growth also is reduced during dry winters by the compounding effects of reduced moisture for plant growth, and intensive cultivation. Reduced food availability apparently results in fewer geese staying in the area. During years when cultivation is prevented by wet conditions, growth of new forage provides a plentiful, high-protein food source for wintering geese (Ballard, 1993).

The variable and low numbers of geese observed during 1990–1991 were probably due to geese stopping for only short periods of time, then moving further south because little food was available in the area to support geese for an extended period. Higher numbers and more uniform temporal distributions of geese during 1991–1992 were apparently the result of more food available during winter.

Geese selectively used disced sorghum habitats on both study areas during 1991–1992, except for snow geese on the Bayside study area. Since disced sorghum was the only disced habitat to contain plant growth, presence of sprouting plants probably attracted geese. Leslie and Chabreck (1984) found that white-fronted geese in Louisiana selectively used cultivated fields rather than rice, soybean, and pasture habitats during mid- and late winter because of sprouting vegetation found in cultivated fields. Owen (1975) found that white-fronted geese selected fertilized rather than unfertilized pastures during winter due to the increase in nitrogen content of grasses. Young, sprouting plants provide high levels of protein for wintering geese (McLandress and Raveling, 1981).

Disced cotton fields were avoided by geese during both study years. Defoliants are applied to cotton fields before harvest, and this apparently minimizes plant growth throughout winter, regardless of moisture.

Preferences by snow geese for habitats with abundant vegetation growth was apparent. Snow geese selectively used improved pasture during both years. Snow geese are adapted to feed on subsurface plant parts (roots, tubers, and rhizomes) more than Canada or white-fronted geese (Bellrose, 1980).

Use of high energy cereal grains in combination with green vegetation by geese has been well documented (McLandress and Raveling, 1981; Hobaugh, 1984, 1985). When grains disappear due to decomposition and consumption, geese move to green vegetation that typically becomes available throughout winter in southern latitudes. Thus, even cultivated grain fields are an important source of food to wintering geese in southern Texas.

Because geese did not differ in percentage of

time spent feeding among habitats, amount of time spent in each habitat was important. Although geese selectively used improved pastures and fallow fields during certain seasons, they spent most of their time in disced sorghum where they apparently found most of their food.

Cropland management for geese and other wildlife can be beneficial in southern Texas, but will be practical only if valuable to farmers. Leaving stubble, residue, or any vegetation growth in fields following harvest is not consistent with current land management strategies of most farmers in south Texas. Research and demonstration showing economic advantages of limited and/or conservation tillage practices in southern Texas are needed to show farmers cropland management practices that enhance soil conservation and benefit wildlife.

Management or privately-owned land is important to wintering geese, especially in states such as Texas where >90% of land is in private ownership (Zekor, 1987). Geese are dependent on agricultural lands for approximately 6 months (October to March) each year. Thus, development of beneficial agricultural practices in both southeastern and southern Texas should be important management considerations.

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