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SANDHILL CRANE USE OF THE MID-PECOS VALLEY OF EASTERN NEW MEXICO

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Abstract: Sandhill cranes (*Grus canadensis*) were monitored during winters 1989–94 in the mid-Pecos River Valley of eastern New Mexico to determine how many used this region following a population decline in the 1980's. Numbers annually increased to a late October/early November peak ($\bar{x} = 7,017$), fluctuated around 6,000 through December, declined in January ($\bar{x} = 3,531$), and again peaked in February/early March ($\bar{x} = 5,737$). Annual crane use-days (weekly counts $\times 7$) varied from 500,545 to 1,007,673 ($\bar{x} = 760,606$). Cranes foraged mainly in corn and sorghum stubble and alfalfa fields. Crop averages (ha) during 1990–92 were alfalfa 21,449, corn 2,462 (cut green for ensilage), sorghum 169 (down from 5,666 ha in 1970), and other crops 6,441. Starting in 1991, Bitter Lake National Wildlife Refuge (NWR) provided 43–55 ha of sorghum and corn. The amount of available food appeared to limit the number of wintering cranes. Hunting disturbances caused approximately 50% of the cranes to leave the valley on 1 occasion, but usually cranes responded by moving from off-refuge sites to protected roosts at Bitter Lake NWR.

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Key words: abundance, *Grus canadensis*, hunting, New Mexico, Pecos Valley, population trend, sandhill crane, winter food.

The Pecos Valley of eastern New Mexico has been recognized as a migration route and wintering area for sandhill cranes since the 1940's. Walkinshaw (1949) reported 5,800 cranes in December 1942, 11,000 in March 1943, and 8,000 in November 1943 at Bitter Lake NWR near Roswell in Chaves County. In December 1960, Boeker et al. (1961) counted 10,229–16,706 at 4 roost sites in Chaves County. Except for Christmas bird count (CBC) data, there were no published records in Chaves County for the next 3 decades. Annual peak numbers of cranes at Bitter Lake NWR, however, were recorded in annual refuge reports. Peak numbers averaged 38,583 during the 1970's and 13,842 during the 1980's, indicating a population decline had occurred in the Pecos Valley. This study documents the numbers of sandhill cranes using the mid-Pecos Valley in Chaves County during 1989–94, identifies the principal factor affecting the numbers of cranes, and assesses croplands preferred by cranes. This information provides insight for managing crane populations and provides a baseline to compare future crane numbers in eastern New Mexico.

This study was a volunteer research project at Bitter Lake NWR. L. Marlatt, former Refuge Manager, suggested the project and provided access to refuge annual reports; W. R. Radke, current Refuge Manager, continued support for the study. M. Peckinpah, refuge volunteer, and refuge staff members M. L. Harper, R. Larrañaga, S. R. Najera, M. E. Rosenbaum, and T. A. Rossignol made weekly crane counts on the refuge. M. L. Burfield helped prepare the final manuscript. I appreciate financial support from a Roy F. Ward Professorship in Natural Science funded by the Kerr Foundation of Oklahoma City, Oklahoma, and administered by New Mexico Military Institute. I thank W. R. Radke for his advice and T. V. Stehn, R. C. Drewien, and an anonymous reviewer for their help and comments on drafts of this manuscript.

STUDY AREA

The study area included agricultural lands surrounding Roswell in southeast New Mexico (Fig. 1). In the Pecos Valley, most farming was confined to 4 areas of irrigated croplands near the communities of Fort Sumner, Roswell, Artesia, and Carlsbad (Fig. 1). Intervening shortgrass prairie separated these areas from each other and from farmlands in west Texas and eastern New Mexico near Muleshoe NWR. The north-to-south orientation of the Pecos River with islands of cropland provided a migration corridor through southeast New Mexico, termed the Pecos Valley Subflyway (Ligon 1961).

Sandhill cranes migrated through and wintered along this corridor, some moving into Mexico (Ligon 1961). The most important winter area was near Roswell in the mid-Pecos Valley where suitable roost sites existed along the Pecos River and food was available in nearby farmlands (Fig. 2).

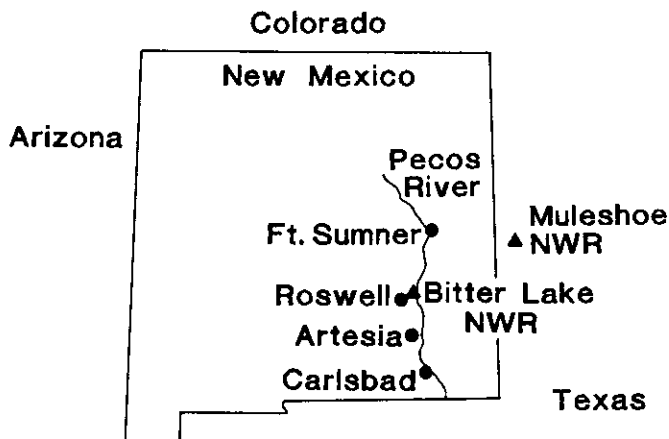


Fig. 1. Location of Roswell and Bitter Lake National Wildlife Refuge in southeast New Mexico.

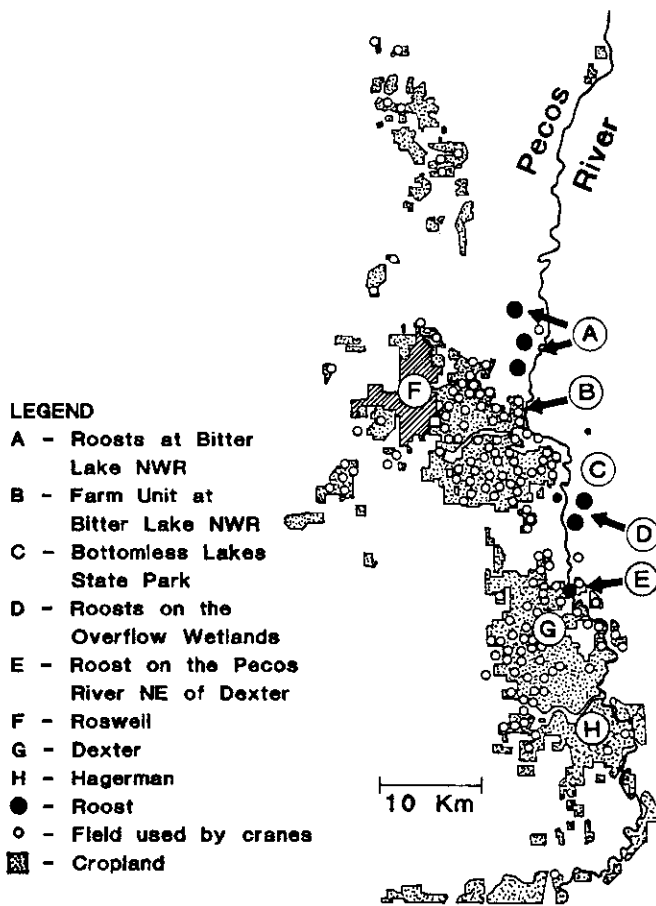


Fig. 2. Areas used by sandhill cranes in the mid-Pecos Valley, Chaves County, New Mexico, during October 1989–March 1995. Map after U.S. Department of Agriculture, Soil Conservation Service (1981).

Approximately 39,580 ha of irrigated cropland occurred in Chaves County (see Methods) and 97% was within 25 km of the Pecos River (Fig. 2). Principal crops (30,310 ha) were alfalfa, cotton, corn, chile peppers, wheat, barley, and sorghum. Only a small portion of the corn crop was harvested for grain; 99% was cut while green for ensilage. Approximately 2,425 ha were in orchards, dairies, and vegetable farms, and the remaining 6,845 ha were either fallow or pasture. Non-croplands were mostly grassland. The average annual rainfall was 27.9 cm (Hodson et al. 1980).

Bitter Lake NWR, 10 km east of Roswell, provided 3 protected roosts and food crops (Fig. 2). Crops, including 40–55 ha of sorghum and corn, were grown for cranes and waterfowl on a 201-ha irrigated farm unit acquired by the refuge in 1988, and millet was occasionally grown on an additional 20 ha of poorly irrigated land. Another major roost was the Overflow Wetlands near Bottomless Lakes State Park on the east side of the Pecos River, 18 km southeast of

Table 1. Annual peak numbers of sandhill cranes (peak) and numbers of sandhill cranes recorded during annual Christmas bird counts (CBC) at Bitter Lake National Wildlife Refuge and the hectares of corn, sorghum, and alfalfa grown in Chaves County, New Mexico, 1969–88.

Year	No. of cranes		Crops (ha)		
	Peak	CBC	Corn	Sorghum	Alfalfa
1969	66,000	9,200	2,226	5,463	15,378
1970	67,000	11,350	2,428	5,666	15,783
1971	23,500	10,512	2,023	3,642	15,662
1972	36,300	4,900	1,355	2,995	15,985
1973	30,300	9,282	1,408	3,076	16,795
1974	12,300	2,400	1,578	2,428	16,107
1975	37,300	9,064	2,185	4,856	16,188
1976	44,500	17,940	2,428	2,914	17,402
1977	70,000	33,090	1,862	1,255	17,807
1978	10,630	352	2,185	2,873	18,009
1979	54,000	6,076	2,550	2,833	18,211
1980	36,200	14,370	2,833	2,428	17,200
1981	18,000	10,226	1,700	1,841	17,402
1982	21,215	8,330	2,550	2,428	20,235
1983	9,005	9,005	1,174	931	20,235
1984	13,900	7,320	1,416	850	20,056
1985	12,000	3,730	1,700	1,255	20,235
1986	11,066	2,500	1,700	1,133	19,425
1987	5,400	2,432	1,072	809	20,235
1988	6,000	4,510	1,740	405	21,044

Roswell (Fig. 2). This roost was important because it was 10–20 km closer than refuge roosts to farmlands in the southern part of Chaves County. The Overflow Wetlands roost, however, was not protected from human disturbance as most of the area was public land administered by the Bureau of Land Management or the state, and crane and waterfowl hunting occurred annually from October to January. The Pecos River, 5 km northeast of the town of Dexter (Fig. 2), and a temporary pond near the Overflow Wetlands were used by smaller numbers (<1,000) of cranes. These lesser roosts were used mainly during winter and spring when water levels were suitable and when cranes moved from the Overflow Wetlands because of disturbance from hunting. A temporary pond north of Bottomless Lakes State Park was also used by $\pm 2,000$ cranes for 2 weeks during January 1992.

METHODS

Trends in crane numbers using the Pecos Valley during 20 years (1969–88) preceding this study were identified by regression analyses of annual peak numbers recorded at Bitter Lake NWR (U.S. Fish and Wildlife Service, unpubl. data,

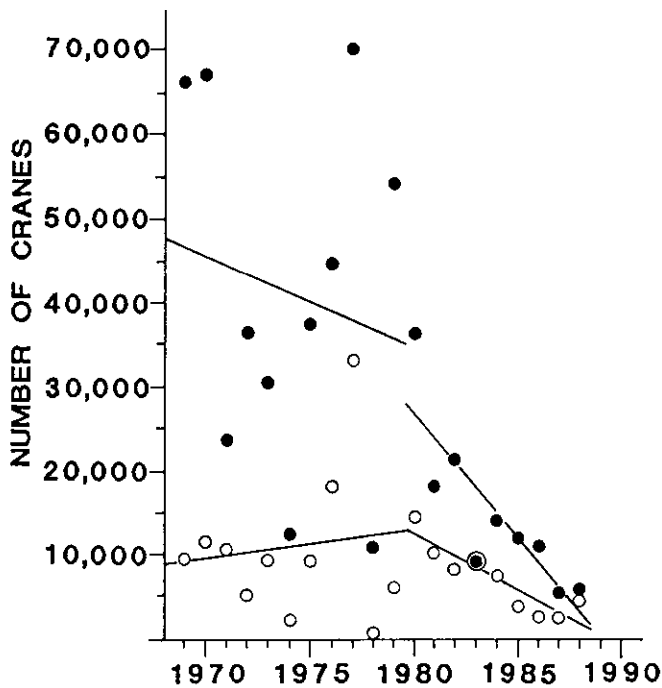


Fig. 3. Trends in annual peak sandhill crane numbers (solid dots) and in numbers of sandhill cranes recorded during annual Christmas birds counts (open circles) at Bitter Lake National Wildlife Refuge, New Mexico, 1969-88. Statistics are included in text.

Annu. Narrative Reps., Roswell, N.M.) and of crane numbers included in annual Christmas bird counts centered on the refuge (National Audubon Society 1970, 1971-89). Relevant agricultural cropland trends in Chaves County during these same years were identified by regression analyses of annual hectares of corn, sorghum, and alfalfa reported annually for New Mexico (U.S. Department of Agriculture 1969-88). Correlation coefficients between annual hectares of these crops and the annual peak and Christmas bird count crane numbers were calculated to assess associations.

Crane numbers were determined weekly by simultaneous dawn counts of roosts at Bitter Lake NWR and the Overflow Wetlands, along with counts obtained during the previous evening along the Pecos River near Dexter or at the temporary pond near the Overflow Wetlands. Weekly counts were usually made by 1 to 4 observers, depending on the number of occupied roosts. When weather conditions prevented accurate censuses, counts were repeated the following day or estimates were used.

Estimates of annual crane use, expressed as crane use-days, were made by multiplying crane numbers times the number of days in the count period to provide insight into the crane carrying capacity of the mid-Pecos Valley.

Observations of daily and monthly patterns of crane activity and field use between October 1990 through March 1993 were obtained from vantage points, by following flying cranes, and by scanning fields while driving through farmlands. It was not possible to randomize searches and observations because the county road net did not accommodate a random search pattern and some fields could not be observed from a public road. Instead, I concentrated searches in areas where cranes were known or suspected to be foraging.

When cranes were located in a field, individuals were counted or their number estimated and the field was classified as (1) alfalfa, (2) stubble (including disked fields with surface plant material), (3) sprouting green field, (4) plowed, (5) grass/prairie, or (6) wet area. Count data were also recorded by time of day, including (1) "early AM" observations made within 2 hours following sunrise, (2) "late AM" observations made during the remaining morning hours, and (3) "PM" observations made after noon, mainly ≤ 3 hours of sunset. Data were converted into percentages for comparisons. Data collections were not randomized because the relative proportions of alfalfa, stubble, and plowed fields changed weekly as farmers worked fields and statistical analyses were not conducted.

RESULTS

Crane Populations and Crop Trends: 1969-79 and 1980-88

Crane counts, both annual peak numbers and CBC's, were analyzed separately for the period 1969-79 and 1980-88 (Table 1, Fig. 3). Peak numbers did not decline during the 1970's ($t = 0.529$, $df = 9$, $P > 0.05$, $Y =$

Table 2. Relationships of annual peak numbers (peak) and Christmas bird count numbers (CBC) of sandhill cranes recorded at Bitter Lake National Wildlife Refuge with annual hectares of sorghum, corn, and alfalfa in Chaves County, New Mexico.

Crop	Years	Correlation coefficients ^a	
		Peak	CBC
Sorghum	1969-79	0.275	-0.304
	1980-88	0.879**	0.689*
Corn	1969-79	0.416	0.088
	1980-88	0.865**	0.596 ^b
Alfalfa	1969-79	-0.014	0.226
	1980-88	-0.666*	-0.582 ^b

^a * $P < 0.05$, ** $P < 0.01$, $df = 7$.

^b The critical value for $P = 0.05$, $df = 7$, is 0.666.

Table 3. Summary of weekly counts of sandhill cranes and annual crane use-days in the mid-Pecos Valley, New Mexico, 1989–94.

Count period	1989	1990	1991	1992	1993	1994
16 Sep–22 Sep	0	0	0	11	16	0
23 Sep–29 Sep	0	17	18	7	20	1
30 Sep– 6 Oct	11	451	139	394	130	74
7 Oct–13 Oct	955	1,692	1,101	2,056	589	4,300
14 Oct–20 Oct	1,920	6,056	3,908	3,295	774	1,420
21 Oct–27 Oct	1,802	5,737	4,653	3,215	1,558	2,550
28 Oct– 3 Nov	5,635	5,599	8,026	6,762	6,578	5,230
4 Nov–10 Nov	4,830	6,046	5,412	6,373	7,925	5,130
11 Nov–17 Nov	5,367	6,608	6,743	6,676	6,999	5,963
18 Nov–24 Nov	4,170	6,052	2,924	6,747	8,882	6,188
25 Nov– 1 Dec	4,830	5,274	4,022	5,726	7,900	6,892
2 Dec– 8 Dec	3,535	6,282	4,536	6,888	8,892	8,193
9 Dec–15 Dec	2,556	6,864	6,143	6,197	7,544	7,880
16 Dec–22 Dec	3,042	7,288	5,909	5,751	10,008	3,959
23 Dec–29 Dec	2,800	5,865	5,021	7,337	9,500	5,509
30 Dec– 5 Jan	3,137	5,750	3,500	5,582	5,530	6,230
6 Jan–12 Jan	3,568	6,600	3,271	5,755	5,432	3,458
13 Jan–19 Jan	3,575	5,309	3,344	6,182	7,109	3,327
20 Jan–26 Jan	3,197	6,163	2,771	2,473	4,785	3,463
27 Jan– 2 Feb	2,878	6,052	3,214	3,213	5,233	3,050
3 Feb– 9 Feb	4,800	6,915	5,103	2,682	6,218	3,154
10 Feb–16 Feb	3,862	5,881	4,349	2,298	7,360	3,550
17 Feb–23 Feb	2,661	4,721	4,825	2,943	6,687	3,640
24 Feb– 2 Mar	1,900	3,241	7,163	2,815	6,301	3,080
3 Mar– 9 Mar	300	2,384	3,729	2,034	7,778	3,950
10 Mar–16 Mar	22	3,857	2,845	2,150	3,084	1,390
17 Mar–23 Mar	86	935	1,262	289	941	633
24 Mar–30 Mar	49	51	138	0	148	104
31 Mar– 6 Apr	0	140	0	0	24	40
7 Apr–13 Apr	0	0	0	0	23	45
14 Apr–20 Apr	0	0	0	0	9	0
Crane-use days	500, 545	894,750	728,483	740,957	1,007,673	691,229

47,761 – 1,114X), but numbers declined ($t = 4.092$, $df = 7$, $P < 0.01$, $Y = 29,413 - 2,932X$) from 1980 to 1988 (Fig. 3). Cranes counted during Christmas bird counts showed no significant trend during the 1970's ($t = 0.115$, $df = 9$, $P > 0.05$, $Y = 8,798 + 309X$), but numbers declined significantly during the 1980's ($t = 5.754$, $df = 7$, $P < 0.01$, $Y = 13,582 - 1,329X$). Changes in agriculture crops occurred in Chaves County during the 1970's and 1980's (Table 1). Sorghum production declined ($t = 7.136$, $df = 18$, $P < 0.01$) from 5,463 ha and 5,666 ha in 1969 and 1970 to 405 ha in 1988. Simultaneously, alfalfa production increased ($t = 9.364$, $df = 18$, $P < 0.01$) from 15,378 ha in 1969 to >20,000 ha in the 1980's. The annual size of the corn crop (20-yr $\bar{x} = 1,908$ ha), however, did not change ($t = 1.370$, $df = 18$, $P > 0.05$). An average of 11.1% of the corn crop was harvested for grain during 1969–75 but increased to 50% during 1976–79 and then fell to 6.6% during 1980–88. Most

corn was cut for ensilage and, along with alfalfa hay, was used to support an expanding dairy industry.

Correlations between annual peak crane numbers and hectares of sorghum and corn were not significant during the 1970's but were significant during the 1980's (Table 2); peak numbers also showed a significant negative correlation ($P = 0.05$) with hectares of alfalfa during the 1980's. Cranes counted during CBC's also showed a similar, but weaker, relationship between numbers and hectares of corn and sorghum (Table 2).

Crane Population Trends: 1989–94

Cranes arrived in the Roswell area in late September/early October; numbers peaked in late October/early November and remained high through December (Tables 3 and 4). Although year-to-year variation occurred within each

Table 4. Means of weekly counts of sandhill cranes at Bitter Lake National Wildlife Refuge and off-Refuge sites in the mid-Pecos Valley, New Mexico, 1989–94.

Count period	Bitter Lake NWR		Off-Refuge site		Total	
	\bar{x}	SE	\bar{x}	SE	\bar{x}	SE
23 Sep–29 Sep	10	3	1	1	11	4
30 Sep– 6 Oct	140	50	60	23	200	73
7 Oct–13 Oct	1,208	554	574	128	1,782	548
14 Oct–20 Oct	1,473	676	1,422	294	2,895	792
21 Oct–27 Oct	1,721	431	1,532	339	3,253	673
28 Oct– 3 Nov	4,012	281	2,293	497	6,305	422
4 Nov–10 Nov	3,712	631	2,241	426	5,953	458
11 Nov–17 Nov	4,144	596	2,249	426	6,393	249
18 Nov–24 Nov	4,596	1,002	1,231	451	5,827	847
25 Nov– 1 Dec	4,603	805	1,171	520	5,774	577
2 Dec– 8 Dec	5,929	935	459	146	6,388	844
9 Dec–15 Dec	5,400	1,000	797	263	6,197	782
16 Dec–22 Dec	5,377	1,277	616	324	5,993	1,012
23 Dec–29 Dec	5,509	915	496	164	6,005	922
30 Dec– 5 Jan	4,395	671	560	194	4,955	529
6 Jan–12 Jan	3,883	612	798	135	4,681	581
13 Jan–13 Jan	3,324	848	1,484	335	4,808	666
20 Jan–26 Jan	1,811	687	1,998	252	3,809	573
27 Jan– 2 Feb	2,639	727	1,301	377	3,940	551
3 Feb– 9 Feb	3,364	664	1,448	308	4,812	678
10 Feb–16 Feb	3,282	776	1,268	367	4,550	736
17 Feb–17 Feb	3,144	708	1,102	277	4,246	608
24 Feb– 2 Mar	3,325	915	758	246	4,083	866
3 Mar– 9 Mar	2,620	1,109	743	470	3,363	1,034
10 Mar–16 Mar	1,826	553	399	183	2,225	558
17 Mar–17 Mar	518	205	173	96	691	181
24 Mar–30 Mar	32	22	50	24	82	24
31 Mar– 6 Apr	0	0	34	22	34	22

weekly count period, the 6-year means show approximately 6,000 cranes remained in the mid-Pecos Valley during the 9 count periods from 28 October to 29 December (Table 4). Average numbers then declined during January and rose again in February. Mean maximum (7,300) and minimum (3,531) winter counts (December and January, Table 3) differed significantly ($t = 4.326$, $df = 5$, $P < 0.01$) but mean fall (7,017) and spring (5,737) migration peaks (Table 3) were similar ($t = 1.418$, $df = 5$, $P > 0.05$).

The timing and magnitude of winter declines in crane numbers varied (Table 3). Numbers declined during December 1989, but no noticeable decline occurred during the 1990 migration and winter season. During the remaining 4 years when sorghum and corn were available on the refuge farm unit, steep declines (≥ 40 –60%) coincided with depletion of these foods in late December and early January. For example, in November 1994 portions of the refuge corn and sorghum plots were made available to birds by periodic

cuttings. In early December, when most cranes and geese in the Roswell area were feeding at the refuge farm, the remaining crops were left uncut in an effort to disperse the wintering goose flock. Crane numbers also subsequently declined from 7,880 on 9 December to 3,959 on 16 December. The remaining crop was then cut and crane numbers rose to 6,600 by 31 December, but the food was quickly consumed and numbers declined to 3,458 by 7 January.

Declines in crane numbers, with 1 observed exception, did not coincide with the opening of crane (mid-October) or duck (mid-November) hunting seasons, although declines in crane use of off-refuge roosts did (Table 4, Fig. 4). During mid-October, crane roosting was evenly divided between roosts at Bitter Lake NWR and off-refuge sites. However, beginning in November and coinciding with disturbances by both crane and waterfowl hunters, roosting declined on off-refuge sites because most cranes moved to the protected refuge roosts. Total crane numbers were not affected, but 1

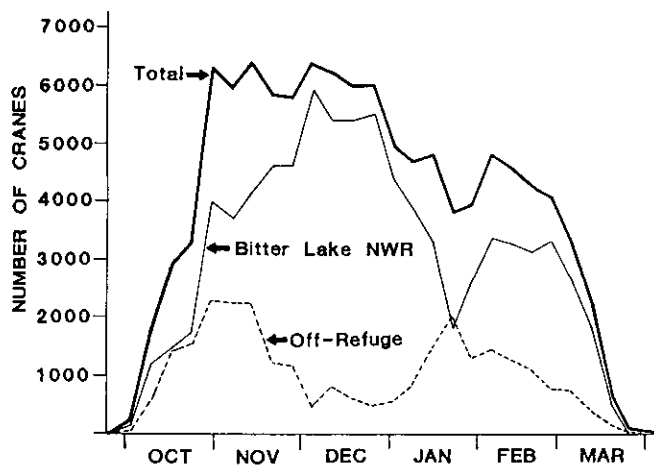


Fig. 4. Mean numbers of sandhill cranes in the mid-Pecos Valley, New Mexico, during the fall and spring migration and winter seasons, 1989-94. Means are from weekly counts at Bitter Lake National Wildlife Refuge and off-Refuge sites in Chaves County.

incident of roost disturbance (of 38 recorded) caused a mass departure (>3,000 cranes, approximately 50% of total) from Chaves County in 1991 (Table 5). Total crane numbers, however, increased again by more than 3,000 during the next 4 weeks.

Field Use

The mean numbers of hectares by crop type in Chaves County during 1990-92 were alfalfa 21,449, cotton 4,789, corn 2,462 (99% cut for ensilage), chile peppers 1,079, wheat 573, and sorghum (all kinds) 169 (U.S. Department of Agriculture 1990-92). Counts of cranes observed in various fields (Table 6) showed that stubble (both corn and sorghum) received the most use. After leaving roosts during early morning hours, cranes either flew directly to stubble fields or, more commonly, gathered in an alfalfa field and then flew to stubble; a similar gathering in alfalfa was observed in afternoons prior to their return to the roost. A seasonal difference in early AM movements was observed. During October, most cranes (75%) flew directly from the roost to stubble. In November, 41.5% flew directly to stubble and in December 82.8% stopped first in alfalfa fields.

Incidental observations also confirmed that cranes were foraging in these crop types. During the 1990 winter when most cranes roosted on Bitter Lake and fed in sorghum fields, droppings at the roost were the characteristic color of sorghum grain (L. Marlatt, U.S. Fish and Wildlife Service, Roswell, N.M., pers. commun.). Examination of the esophagi of 3 cranes killed during 1990 revealed 2 were filled with corn kernels and 1 contained corn kernels, 16 alfalfa

Table 5. Weekly counts of sandhill cranes at Bitter Lake National Wildlife Refuge and off-Refuge sites in the mid-Pecos Valley, New Mexico, before and after the start of the 1991 duck hunting season. The season opened on 16 November.

Date	Bitter Lake NWR	Off-Refuge sites	Total
8 Nov	2,802	3,330	5,412
15 Nov	3,511	3,232	6,743
22 Nov	2,814	110	2,924
29 Nov	3,879	143	4,022
6 Dec	4,006	530	4,536
14 Dec	5,587	556	6,143

leaflets, and a grasshopper.

Two other cropland types were used to a lesser extent for foraging. Sprouting green fields were used when the seeds were germinating and young plants were emerging, but cranes vacated these fields once plants were established. Flock sizes in these fields varied (\bar{x} = 228, SE = 64.5, range 3-2,000, n = 35). Recently plowed fields were used by smaller flocks (\bar{x} = 48, SE = 7.3, range 3-275, n = 67) for several days until the soil dried.

Cranes were not observed in cotton, chile peppers, or other crops except when these fields were losing or had lost their identity by disking or plowing. Crane observations in these latter fields were included in the "plowed" category.

The preceding observations were obtained in private farmland where food for wildlife was considered incidental to normal farming operations. Bitter Lake NWR began growing wildlife crops in 1989 on a 201-ha farm unit. Coinciding with a 55-ha planting of sorghum in 1991, cranes began using the refuge farm. During 1991 and subsequent years, they foraged mostly in sorghum and corn.

Although cranes foraged in alfalfa, especially during morning hours, they also used alfalfa fields for diurnal resting sites. Cranes also rested near small ponds and marsh areas not used for roosting, particularly in October and November (Table 6). Cranes occasionally used prairie during early morning after leaving roosts, but they usually flew to agricultural fields within the hour.

Daily Activity

The typical daily activity pattern was a mass morning flight from the roost to the farmland and a return in small groups from mid-morning through the afternoon or a mass return to the roost at sunset. Smaller afternoon flights from resting areas and roosts to farmlands also occurred. After departing roosts in the morning, cranes usually congregated in the first alfalfa fields they encountered before flying on to

Table 6. Distribution (%) of sandhill cranes in different field types, mid-Pecos Valley, New Mexico, October 1990–March 1993^a.

Month and time of day ^b	% of observations by field type ^{c,d}						
	No.	ALF	STB	SGF	PLW	G/P	WET
October							
Early AM	19,149	23.5	75.0	0.0	0.0	1.5	0.0
Late AM	3,938	17.3	82.7	0.0	0.0	0.0	0.0
PM	9,103	31.0	11.2	1.9	0.0	0.6	55.3
November							
Early AM	19,689	44.6	41.5	6.6	0.7	6.6	0.0
Late AM	7,982	43.2	52.1	4.7	0.0	0.0	0.0
PM	17,520	18.7	36.1	7.7	0.0	6.3	31.2
December							
Early AM	7,925	82.8	13.4	3.8	0.0	0.0	0.0
Late AM	5,038	34.7	46.5	18.8	0.0	0.0	0.0
PM	9,371	74.3	25.1	0.0	0.0	0.6	0.0
January							
Early AM	6,805	77.2	18.5	0.6	3.7	0.0	0.0
Late AM	4,575	11.0	84.1	4.1	0.8	0.0	0.0
PM	17,015	25.0	56.1	0.0	1.9	0.0	17.0
February							
Early AM	11,754	77.4	17.7	1.2	3.7	0.0	0.0
Late AM	10,731	12.6	62.7	20.2	4.4	0.0	0.1
PM	19,011	48.8	37.4	1.6	5.3	0.0	6.9
March							
Early AM	12,380	69.1	12.9	0.0	3.3	14.7	0.0
Late AM	5,824	38.7	59.6	0.0	1.7	0.0	0.0
PM	11,024	65.4	26.1	6.4	0.2	0.2	1.7
All months combined							
Early AM	77,702	55.0	36.7	2.3	1.6	4.4	0.0
Late AM	38,088	26.2	62.5	9.7	1.6	0.0	0.0
PM	83,044	40.7	35.2	3.1	1.6	1.5	17.9

^a Bitter Lake National Wildlife farm not included.^b Early AM = ≤2 hours after sunrise, late AM = remaining morning hours, PM = all afternoon hours, mostly ≤3 hours before sunset.^c ALF = alfalfa, STB = corn or sorghum stubble, SGF = sprouting green field (germinating wheat, alfalfa, or barley), PLW = plowed field (no stalks visible), G/P = grass or prairie, and WET = wet area.^d No cranes were observed in cotton, chile peppers, or other field crops.

stubble fields to feed. Before returning to the roost in late afternoon, cranes often congregated in alfalfa fields or wet areas. During January, however, more cranes remained in stubble fields until sunset (Table 6).

Foraging cranes were not randomly distributed, but generally concentrated in a few fields. For example, in December 1990 and January 1991, more than 90% of the cranes in Chaves County used 1 roost (at Bitter Lake NWR) and flew 22 km northwest to feed in 168 ha of sorghum fields that were left undisked for livestock foraging. Similarly,

during spring 1993, up to 5,000 cranes foraged daily in a 45-ha corn field grown for grain and left undisked for livestock. Most cranes from a roost foraged as a single flock in 1 area for several days to weeks and then, in response to food depletion or disturbances, moved to another area. Locations of fields used by cranes are shown in Figure 2. Some fields were used throughout the study, but most were used only 1 or 2 years and were fallow, planted in other crops, or converted to other uses in other years.

DISCUSSION

Crane numbers in the mid-Pecos Valley during 1989–94 rose to an initial migratory peak in late October/early November, averaged ±6,000 through December, and then declined significantly. This decline appeared to be related to available food, and food was apparently the principal factor limiting winter population levels. During the 1991–94 seasons, crane numbers declined sharply when food on the refuge farm was depleted. In contrast, a winter decline did not occur during the 1990 season when most cranes used an apparently rich food source northwest of the refuge. Annual peak numbers at Bitter Lake NWR were also correlated with hectares of corn and sorghum during the 1980's when both crane numbers and amount of sorghum grown annually were decreasing.

Hunting also affected numbers and distribution during 1989–94, but not as severely as reported by Boeker et al. (1961). They observed a 96% decline in the crane population in Chaves County within 2 weeks after the start of the first crane hunting season. Lovvorn and Kirkpatrick (1981) summarized studies also showing population shifts and roost abandonment following the opening of waterfowl seasons in various regions of the United States. Although 1 hunting-caused mass departure was recorded in Chaves County, crane numbers generally remained high throughout crane and waterfowl seasons. Cranes usually responded to hunting disturbances by moving to protected roosts at Bitter Lake NWR.

Observations of field use, esophageal contents, and droppings at the roost noted in my study were consistent with other studies in New Mexico and west Texas. Boeker et al. (1961) reported that cranes in the Roswell area mainly ate sorghum and green alfalfa. Walker and Schemnitz (1985) found corn, sorghum, and alfalfa were the principal foods in central and southwestern New Mexico. They noted that grasshoppers also were important in the diet and concluded that most were consumed when cranes were foraging in alfalfa.

Iverson et al. (1985a) observed large increases in crane numbers in west Texas between January and mid-February.

Similar increases occurred in early February in the mid-Pecos Valley. Iverson et al. (1985b) also reported that cranes landed in milo (sorghum) or cotton stubble soon after leaving roosts and later concentrated in milo stubble farther from roosts. During afternoons, large flocks gathered in cotton stubble near roosts. A similar pattern was observed in this study, but alfalfa fields (not present in west Texas) and wet areas replaced cotton stubble as gathering areas in the Pecos Valley.

MANAGEMENT IMPLICATIONS

How many cranes can the mid-Pecos Valley support with current food resources? The amount of off-refuge food varied annually but was sufficient in 1990 to support 5,000–6,000 cranes throughout most of the winter. Bitter Lake NWR provided a more consistent food supply, but the amount was insufficient to sustain recent wintering numbers beyond mid-January.

The number of crane use-days gives a measure of the amount of use the mid-Pecos Valley receives during a winter season and, therefore, provides an indirect measure of available food resources. The 6-year average was 760,606 crane use-days. If agriculture production remains constant, food resources should be sufficient to maintain approximately 4,700 cranes from 7 October through 16 March (161 days) or larger numbers for shorter periods. Because the number of cranes annually exceeds this level, a winter decline is inevitable unless more food is provided as in 1990.

Food provided by Bitter Lake NWR since 1991 has attracted the majority of cranes remaining in the Roswell area through December. If the management goal is to increase crane numbers wintering in the mid-Pecos Valley beyond December, then additional food crops are needed. Agricultural trends on private lands, however, have been toward smaller sorghum crops and earlier disking and plowing of corn stubble. It is also unlikely that food production will be increased at Bitter Lake NWR due to budget restrictions, limited availability of suitable cropland, and a possible reduction in allocated water. Or, if the management goal is to maintain a smaller, but constant, number throughout the winter, then food grown on the refuge should be rationed by

carefully monitored cuttings to encourage part of the population to winter elsewhere. However, if the goal is to maintain a larger number of cranes in the Roswell area until the end of the hunting season, the current practice of making all food on the refuge available in November and December should remain unchanged.

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