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DISTRIBUTION AND ABUNDANCE OF LARGE SANDHILL CRANES, *GRUS CANADENSIS*, WINTERING IN CALIFORNIA'S CENTRAL VALLEY[1]

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Abstract. Distribution and abundance of large sandhill cranes (*Grus canadensis tabida*, Greater Sandhill Crane, and *Grus canadensis rowani*, Canadian Sandhill Crane) were studied in California's Central Valley during October–February 1983–1984 and 1984–1985. We estimated that the population contained 6,000–6,800 cranes which were concentrated at eight geographic locations from Chico to Pixley National Wildlife Refuge (NWR) near Delano. Ninety-five percent of the population occurred in the Sacramento Valley and the northeastern Sacramento-San Joaquin Delta (S-SJ Delta); portions of the winter range varied seasonally in their importance to the population in both winters. More than half the population used the Butte Sink region in the Sacramento Valley during October–November. From December through January the Thornton and Cosumnes regions on the S-SJ Delta hosted 56–76% of the population. Sightings and locations of 157 color-marked and 10 radio-tagged Greater Sandhill Cranes confirmed the movements of the population among different portions of the winter range. Most wintering sites were in private ownership, and the majority of the nocturnal roosting sites were privately owned waterfowl hunting areas. Present population estimates range from 2.5 to 2.9 times the estimates of the late 1960s and mid-1970s; differences are largely explained by variation in the effort between this and earlier studies, and the increased concentration of cranes at wintering sites in the 1980s. More than half of the wintering population may originate in coastal and interior British Columbia. Cranes originating in Canada may belong to different breeding populations than those originating in Oregon and California, although they are sympatric during the winter. Studies of the cranes from British Columbia are needed to clarify the status of the large sandhill cranes wintering in California's Central Valley.

Key words: *Greater Sandhill Crane;* Grus canadensis tabida; *Canadian Sandhill Crane;* G. c. rowani; *wintering distribution; abundance; California's Central Valley; population status.*

INTRODUCTION

Four populations of Greater Sandhill Cranes are recognized: the Eastern, Rocky Mountain, Lower Colorado River, and Central Valley Populations (Braun et al. 1975, Lewis et al. 1977). The Central Valley Population winters in agricultural areas on the floor of California's Central Valley and nests in northeastern California, eastern Oregon, and in British Columbia west of the Continental Divide of the Rocky Mountains (Littlefield and Thompson 1979, U.S. Fish and Wildlife Service [U.S.F.W.S.] 1983). The segment of the population spending the summer in Oregon and California has been estimated at 3,200–3,400 individuals (Stern et al. 1987, Littlefield 1989), and the number spending the summer in British Columbia has been stated to be 600 (U.S.F.W.S. 1983).

The U.S.F.W.S. included the Central Valley Population on its Sensitive Species List (U.S.F.W.S. 1982a) because of low productivity of Sandhill Cranes nesting at Malheur NWR, in southeastern Oregon (Littlefield 1976), threats to nesting habitat in Oregon and California (Littlefield and Thompson 1979, Littlefield 1982), and destruction of wetland habitat at wintering areas in California's Central Valley (Gilmer et al. 1982). In 1983 the California Game Commission listed

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the population as Threatened under California's State Endangered Species Act. The Pacific Flyway Management Plan for the Central Valley Population of Greater Sandhill Cranes (U.S.F.W.S. 1983) recommended winter surveys to provide indices of the size of the population and monitor winter distribution. This study was conducted to accomplish these goals. The specific objectives of this paper are to: 1) present recent estimates of the population's size, 2) delineate and identify important wintering sites, 3) describe winter movements, and 4) discuss the status of the population.

STUDY AREA

California's Central Valley is approximately 640 km long and averages 65 km in width, encompassing approximately 41,500 km^2. Topography is generally flat and the valley is dissected by numerous rivers and streams. Elevations on the valley floor range from 14 m above mean sea level (M.S.L.) at Chico to 3–7 m below mean sea level on the S-SJ Delta. California white oak (*Quercus lobata*) woodlands, grasslands, and wetlands present in the valley in the late 1800s have been drastically reduced and altered by agricultural and urban development, flood control, water diversion, and drainage projects (Holstein 1984, Katibah 1984, Gilmer et al. 1982). Approximately 11% of the riparian woodlands present in the Central Valley in 1848 remained in 1984 (Katibah 1984), and less than 6% of the 16,000 km^2 of wetlands present in 1850 remained in 1980. Sixty-nine percent of the wetlands remaining in the early 1980s were in private ownership (Gilmer et al. 1982). Heitmeyer et al. (1990) described the wetland habitats in the Central Valley. Agriculture is the primary land use, with orchards, cereal grains, and row crops dominating. The climate consists of warm dry summers (mean high and low temperatures in July are 35.7° and 16°C, respectively), and cool, wet winters (mean high and low temperatures in January are 13.4° and 3.6°C, respectively). Seventy-five percent of the approximately 33 cm average annual precipitation falls as rain from October through March (U.S. Dep. Comm. 1985). Periods of dense ground fog, lasting up to several weeks, are common during winter.

The study area included the entire Central Valley, but intensive ground surveys were conducted in eight geographic regions which encompassed approximately 1,500 km^2 (Fig. 1). The three northern regions of the intensive study area, Chico, Afton, and the Butte Sink, are contiguous and are located in the eastern Sacramento Valley. These three regions extend from the Sacramento River east to within 1 km of Highway 99. The Chico region comprises 510 km^2 and extends from the city of Chico south to Highway 162, while the Afton region includes 240 km^2 and extends from Highway 162 south to the Colusa-Gridley Highway. The Butte Sink region comprises 300 km^2 and extends from the Colusa-Gridley Highway south to near Highway 20 and east to the vicinity of Gridley and the base of the Sutter Buttes. Rice culture, natural vegetation (riparian woodlands, annual grasslands, and pastures), and orchards covered 38, 20, and 10%, respectively, of the 1,055 km^2 eastern Sacramento Valley (California Dep. Water Res., unpubl.). During winter, flooded ricelands, pastures, and areas of native and managed marshes, covering approximately 20% of the Butte Sink region (Heitmeyer et al., 1990), provided important waterfowl habitat and hunting areas.

The two study regions in the mid-Central Valley, Thornton and the Cosumnes, are located on the northeastern S-SJ Delta. The Thornton region comprises 240 km^2 and extends from Walnut Grove and Thornton south to Highway 12, and from Grand Island east to Interstate 5. The Cosumnes region includes 90 km^2 on the floodplain of the Cosumnes River from Highway 99 south to the Mokelumne River, and from Interstate 5 east to the vicinity of Galt. On the S-SJ Delta, the most important crops and land uses were corn, pastures, and vineyards, which covered 30, 15, and 12% of the region, respectively (California Dep. Water Res., unpubl.). Waterfowl hunting areas on the S-SJ Delta were created by flooding harvested grainfields and pastures, and made up approximately 3% of the region.

To the south, the Modesto region, located in the northern San Joaquin Valley, includes 110 km^2 at the confluences of the Stanislaus, Tuolumne, and San Joaquin rivers 16 km west of Modesto. Dominant land uses in the Modesto region were pastures (47%), row crops (16%), cereal grains and orchards (12% each) (California Dep. of Water Res., unpubl.). Waterfowl hunting areas were not a prominent feature of this region. Less intensive surveys were also conducted in the vicinity of Merced NWR and Pixley NWR in the central and southern San Joaquin Valley.

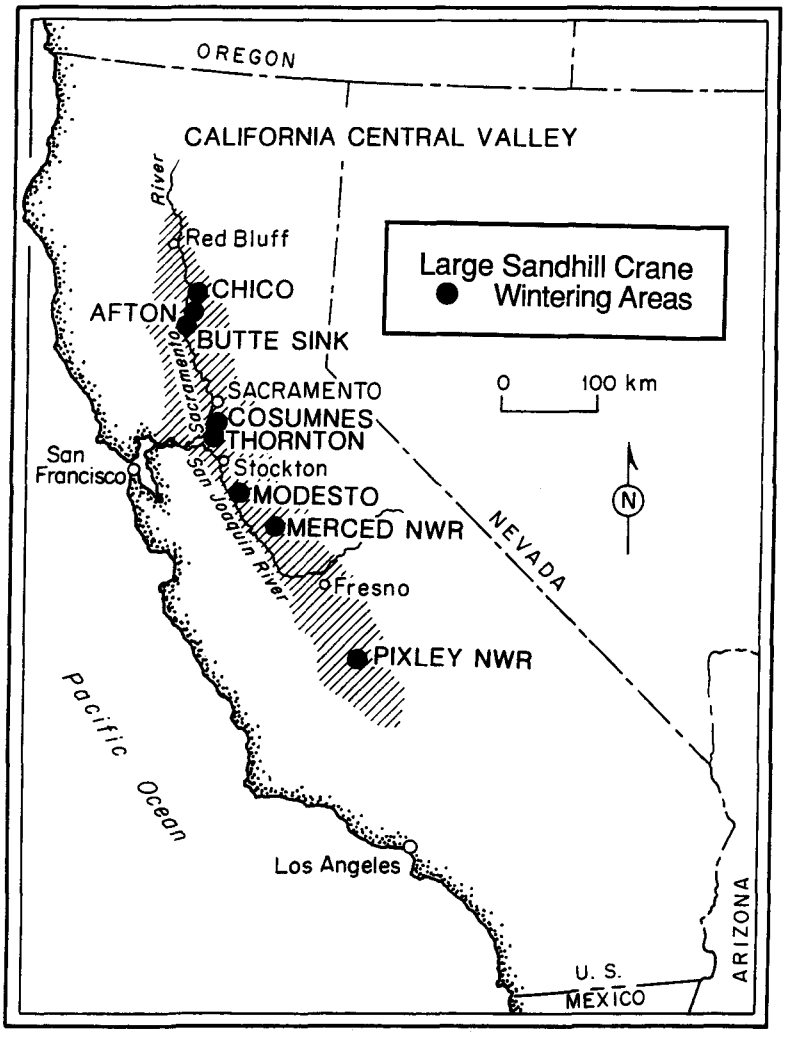

FIGURE 1. Wintering areas of Greater Sandhill Cranes in California's Central Valley during 1983–1984 and 1984–1985.

METHODS

DISTRIBUTION

During the winter of 1982–1983 we conducted a postcard questionnaire survey soliciting reports of cranes in California's Central Valley from 200 sources including: biology and wildlife departments of California colleges and universities, local chapters of the Audubon Society, the California Department of Fish and Game, and the U.S.F.W.S.

In December 1981, February and October 1982, and December 1982–January 1983 we conducted 6,300 km of roadside surveys during 44 person-days in the field while censusing Pacific Flyway Population Lesser Sandhill Cranes (*G. c. canadensis*) at Thornton, Modesto, Merced, and other regions of the San Joaquin Valley. From 23 September 1983 to 27 February 1984 and 19 October 1984 to 2 March 1985, we conducted 26,400 km and 19,680 km of roadside surveys during 142 and 123 person-days, respectively. During the surveys, we mapped the distribution of cranes and conducted counts to estimate their abundance. We interviewed 169 farmers, waterfowl hunters, state and federal game wardens and biologists, and members of the gen-

eral public during this period seeking information on the distribution of cranes. We participated in five aerial surveys of the Sacramento Valley and the S-SJ Delta between October 1983 and February 1985. We also investigated the occurrence of cranes beyond the limits of the intensive study areas to delineate the boundaries of the population's distribution. The Central Valley is also the principal wintering area of the Pacific Flyway Population of Lesser Sandhill Cranes (Littlefield and Thompson 1982); therefore, we attempted to visit all locations from which we received reports of any cranes to determine subspecific composition.

ABUNDANCE

We estimated the size of the Central Valley Population by conducting monthly censuses during October 1983–January 1984. Complementary sets of counts from each region were selected and summed to estimate the size of the population for each month (see below).

Our objective was to obtain complete counts in each region in as short a period of time as possible to avoid duplicate counting of individuals which moved between sites. To accomplish this objective we identified important sites used by cranes and then conducted a series of censuses at all sites which simultaneously hosted cranes. We censused two sites simultaneously whenever possible and conducted censuses at additional sites on successive days to obtain a complete count from each region.

To census individuals we counted flying cranes at dawn as they left roost sites, or when they returned to these roosts in the evening. During these counts we scanned flocks of cranes with binoculars, individually counted the birds in flight, and recorded the number of individuals with multiple-field tally meters. We conducted the roost counts from platforms 1.5–2.0 m high constructed over the beds of pickup trucks or from vantage points which permitted unobstructed views. We also conducted roadside surveys during mid-day in areas where cranes were dispersed and where roost counts were an inefficient method for estimating the number of individuals present. We conducted 71 dawn and dusk roost censuses at 21 different sites, 33 during morning flights and 38 in the evening; and 44 daytime censuses at 24 different sites in all four months. After completing a series of counts in each region, we selected and summed 1–6 complementary (i.e., one from each site containing cranes) counts/region to calculate regional population estimates for each month. We selected the series of counts included in each regional population estimate to minimize the probability of counting the same individuals at more than one site. Roost counts and daytime counts were not conducted in the same regions to avoid counting individuals at more than one site. The series of counts in each region were always completed within 1–7 days. The chronology of the counts which were summed to estimate the population's size are presented in Table 1.

When conducting counts in regions with both Lesser and Greater Sandhill Cranes, we distinguished Lesser Sandhill Cranes by their small body size, high pitched calls, active demeanor, shape of their heads, the length and shape of their bills, and the length of their bills relative to the size of their heads (Fig. 2). At some locations we noted the presence of cranes which appeared intermediate the size between Greater and Lesser Sandhill Cranes. These intermediate-sized birds resembled Canadian Sandhill Cranes, *G. c. rowani* (Walkinshaw 1965), which probably originated in British Columbia (Littlefield and Thompson 1979, U.S.F.W.S. 1983, Campbell et al., 1990). We included the intermediate cranes in the estimates of the size of the Central Valley Population because they were distinguishable from Lesser Sandhill Cranes but were not consistently distinguishable from Greater Sandhill Cranes. Thus, our population estimates represent the number of "large cranes" (including Greater and Canadian Sandhill Cranes), present on the winter grounds in the Central Valley. This approach is consistent with the definition of the Central Valley Population in the Pacific Flyway Management Plan (U.S.F.W.S. 1983).

MARKED CRANES

To describe population movements, verify our assumptions about distribution, and find additional wintering sites used by the population, we observed color-marked and radio-tagged cranes. Between 1966 and 1984, 345 cranes were marked at Malheur NWR, an important nesting and fall staging area (Littlefield 1986) in southeastern Oregon. In 1983 and 1984, 39 cranes were marked at Sycan Marsh, a nesting area in southcentral Oregon, and in 1984, eight cranes were marked at Modoc NWR, a nesting area in northeastern California.

TABLE 1. Numbers of large sandhill cranes counted in California's Central Valley, Winter 1983–1984. Missing values indicate no data were collected.

Regions / Locations	October		November		December		January	
	Date	No. cranes	Date	No. cranes	Date	No. cranes	Date	No. cranes
Chico								
A. Fenn's	20	216	21–22	X	20	X	23–24	X
Llano Seco Rancho	20	X	22	257	20	455	23	560
M&T Ranch	20	X	21	424	20	262	23	394
Nelson		—		—	20	69	24	169
Sub-totals		216		681		786		1,123
Afton								
Schorr Ranch	10–20	0	17–20	0	20	688	24	0
Terhel Farms	10–20	0	17–20	0	20	0	24	233
Sub-totals		0		0		688		233
Butte Sink								
Bean Patch[e]	19	1,500	19–20	X	19–20	0	26	0
Brady Ranch	18	1,168	20	2,246	20	469	26	231[a]
Butte Basin Farm	18	509	19	934	19	60	26	0
Gray Lodge W.M.A.[e]	17	702	19–20	X	20	630[b]	26	0
Sub-totals		3,879		3,180		1,159		231
Thornton								
Canal Ranch	25	296	27	35	12	467	28	X
Cortopassi Farms	22–28	0	27–30	0	11	393	28	X
E. Merlo & Sons	26	188	30	279	12	635	28	X
El Dorado	24	475	30	909	12	709	28	2,195
Grand Island	—	—	26–30	0	16	675	28	0
Staten Island	24	813	29	845	9	595	28	1,634
Sub-totals		1,772		2,068		3,474		3,829
Cosumnes	26	65	3	197	7	238	29	1,390
Modesto								
Faith & Mape's R.	5	80	29[c]	128	28	142	—	—
Bogetti Farms	—	—	—	—	28	84	—	—
Sub-totals		80		128		226		—
Merced NWR	—	—	—	—	1[d]	32	—	—
Pixley NWR	—	—	—	—	3[d]	14	—	—
Totals		6,012		6,057		6,617		6,810

X = Large sandhill cranes which probably represent the same individuals counted at a different site on the same day.
[a] Cranes counted on the Brady Ranch and surrounding lands.
[b] Cranes counted in the vicinity of Gray Lodge W.M.A.
[c] 29 October 1983.
[d] January.
[e] Managed for wintering waterfowl by state and federal agencies.

RESULTS

DISTRIBUTION AND ABUNDANCE

Central Valley Population cranes, including Greater and Canadian Sandhill Cranes, began arriving on their wintering areas the third week of September, and by late October most were present in California's Central Valley. The population wintered at eight regions during the winters of 1983–1984 and 1984–1985 (Fig. 1), and the distribution of the population varied seasonally among the regions of the winter range (Table 1). More than half of the population used the Butte Sink during October and November, but only 18 and 3% of the population used this region in December and January, respectively. Declines in the use of the Butte Sink corresponded with an increase at Chico, Thornton, and in the Cosumnes region. Thornton replaced the Butte Sink as the most important winter area in December, supporting 53% of the population. In January, Thornton and the adjacent Cosumnes River floodplain supported 76% of the population.

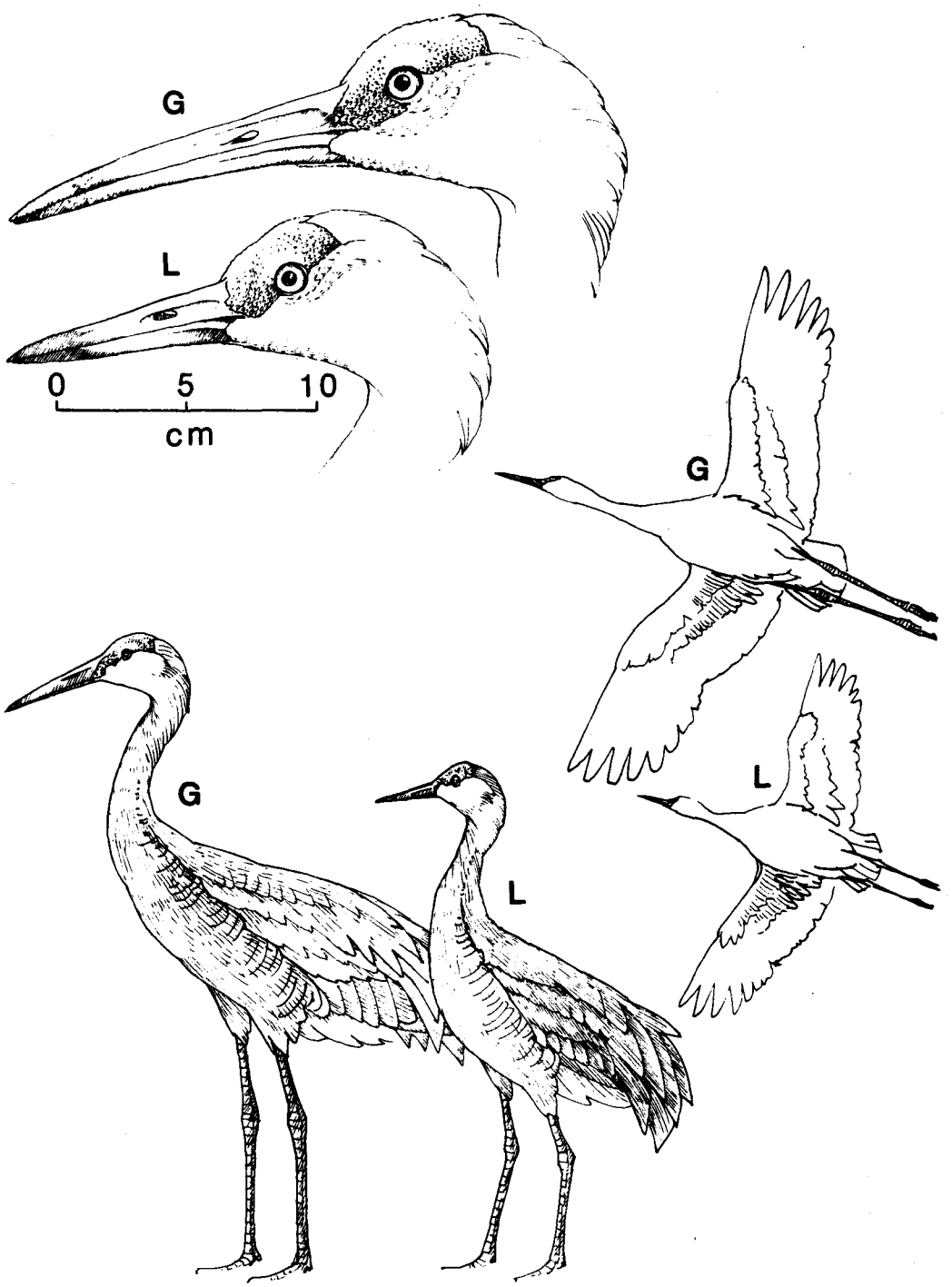

FIGURE 2. Comparison of Greater (G) and Lesser (L) Sandhill Cranes for field identification.

TABLE 2. Seasonal distribution of color-marked and radio-tagged Greater Sandhill Cranes[a] in California's Central Valley during the winters of 1983–1984 and 1984–1985. Missing values indicate no data were collected.

Locations	No. of marked cranes				
	Oct	Nov	Dec	Jan	Feb
Chico	4	6	5	12	14
Afton	0	10	6	0	0
Butte Sink	8	38	21	5	5
Thornton	99	116	135	152	117
Cosumnes	1	—	8	3	20

[a] Marked at Malheur NWR and Sycan Marsh in southeastern and southcentral Oregon, respectively, and Modoc NWR in northeastern California.

Numbers of large cranes using the Chico region increased from October to January, and use of the Modesto region increased from October at least until December. Use of the Afton region was short-lived; cranes began using the area in late November, but declined after December. In both winters, small flocks of cranes (containing <30 individuals) only occurred west of the Sacramento River on Colusa, Delevan, and Sutter NWRs in October and November (fall migration) (Sacramento NWR, unpubl. data). Four monthly estimates indicated the population of large cranes numbered between 6,012–6,810 individuals (Table 1).

SIGHTINGS OF MARKED CRANES

We observed 157 color-marked and 10 radio-tagged cranes during 1983–1984 and 1984–1985, representing at least 86 and 82% of the marked cranes known to be alive each season (based on sightings at nesting, staging, and wintering areas through December 1988), respectively. Marked cranes were observed at all important regions used by the population, although the number in each region varied among months (Table 2). The seasonal pattern of sightings paralleled the seasonal pattern of abundance estimated by population counts (Tables 1 and 2). In the Butte Sink the largest numbers of marked cranes were observed during November and December, the only months when marked birds were present at Afton. The largest number of marked cranes at Chico occurred in January and February. At Thornton, the number of marked cranes increased from October through January, while on the adjacent floodplain of the Cosumnes River, peak numbers of marked birds occurred in February. The number of marked cranes observed at Modesto increased in December and most of these remained until February.

Marked cranes moved among regions in both years (Table 3). Forty-five percent of the marked cranes observed in the Butte Sink (from October–December) were resighted at other locations (between November–February). Fifteen percent which were observed in the Butte Sink moved north and were resighted at Afton and Chico. Thirty-six percent of the marked cranes first observed in the Butte Sink were later resighted at the Thornton and Cosumnes regions on the S-SJ Delta. Twelve percent of the marked cranes observed at Thornton were later resighted in the Cosumnes region. This pattern of movement confirmed that the seasonal changes in the abun-

TABLE 3. Winter movements of color-marked and radio-tagged[a] Greater Sandhill Cranes in California's Central Valley during the winters of 1983–1984 and 1984–1985. CHI = Chico, AFT = Afton, BSK = Butte Sink, THR = Thornton, COS = Cosumnes, MOD = Modesto.

First sightings		Locations of resightings					
Locations	No. marked cranes	CHI	AFT	BSK	THR	COS	MOD
Chico	20		1		1[b]		
Afton	11	1			1		2
Butte Sink	53	3[c]	5		19[d]	4[e]	
Thornton	146					16	
Cosumnes	5				2		
Modesto	12						
Pixley NWR	1						

[a] Marked at Malheur NWR and Sycan Marsh in southeastern and southcentral Oregon, respectively, and Modoc NWR in northeastern California.
[b] Previously resighted at Afton.
[c] One individual previously resighted at Afton and Thornton.
[d] Two individuals previously resighted at Afton.
[e] All previously resighted at Thornton.

dance of cranes within regions resulted from the movement of cranes among regions.

IMPORTANT WINTERING SITES

The most important sites used during October and November were the Bean Patch, Brady Ranch, and Gray Lodge Wildlife Management Area (WMA) in the Butte Sink region, each of which supported 12–37% of the entire population (Table 1). In the Thornton region, the El Dorado Gun Club and Staten Island Ranch each supported 8–15% of the population during October and November (Table 1). During December, approximately 80% of the cranes were dispersed at numerous nocturnal roosting sites in the Chico, Afton, and Thornton regions, none of which supported more than 4–11% of the population. The roosting sites provided by waterfowl hunting clubs at Thornton were drained at the end of the hunting season in mid-January. During the last week of January more than half of the population, 3,829 cranes, concentrated in 295 ha in two roosting sites at Thornton: Staten Island Ranch (235 ha) and the El Dorado Gun Club (60 ha), and supported 25 and 41% of the total, respectively (Table 1). These roost sites were waterfowl hunting areas that were drained, and they dried out at the end of January. In late January and early February, large numbers of cranes left the Thornton region and moved to the adjacent floodplain of the Cosumnes River, where 24% of the population concentrated in the flooded riparian woodlands, meadows and pastures near the river (Table 1). This movement to the floodplain occurred in both winters.

DISCUSSION

ABUNDANCE

The consistency of our estimates of the size of the Central Valley Population (Table 1) indicated that at least 6,000 Greater and Canadian Sandhill Cranes winter in California's Central Valley. The two lowest estimates occurred in October and November, when fall migration was still underway and not all large cranes had arrived at their wintering areas (Littlefield 1986; M. Stern, pers. comm.). Higher population estimates during December and January occurred after the arrival of cranes on the winter grounds, and after cranes had concentrated on the S-SJ Delta when censusing conditions improved. Our estimates of the population size were approximately 30% higher than two other recent estimates of the number of cranes in the Central Valley Population. Simultaneous counts of cranes in eastern Oregon and northeastern California during fall migration in 1985 estimated a total of 5,292 Greater Sandhill Cranes (C. D. Littlefield, pers. comm.). A second and independent estimate of the population's size suggested a population of at least 5,313 individuals (Littlefield 1986, Stern et al. 1987, C. D. Littlefield, pers. comm.). Both of these probably represent underestimates because they assumed that all cranes in the population were counted at fall staging areas in eastern Oregon and northeastern California, which is unlikely.

Littlefield and Thompson (1979) counted between 2,359–2,553 large cranes of the Central Valley Population at wintering areas during the winters of 1969–1970, 1970–1971, and 1976–1977. Three factors may have contributed to the greater than two-fold increase between these counts and ours: 1) an increased concentration of the population on winter areas, 2) differences in the geographic coverage between the two studies, and 3) increases in the size of certain segments of the population (see Status of the population).

Probably because of changes in winter habitats in the last two decades, the population was concentrated at fewer sites in the 1980s compared to the late 1960s and mid-1970s. In December 1983, we counted 4,500 Greater Sandhill Cranes in the same areas of the Central Valley where Littlefield and Thompson (1979) found 2,359–2,553 Greater Sandhill Cranes in December of 1969, 1970, and 1976, suggesting that the population could have been almost twice as concentrated on its winter range in the 1980s. On the S-SJ Delta, the area of harvested corn increased from an average of 16,300 ha in 1969–1971 to 28,100 ha in 1980–1982, replacing dairy pastures, meadows, and asparagus as the dominant land use (San Joaquin Co. Agric. Commission, unpubl.). Waste corn is an important food for sandhill cranes during the non-breeding season (Reinecke and Krapu 1979, Iverson and Tacha 1982, Walker and Schemnitz 1987) and contains higher levels of lipids, protein, and energy than rice, and higher levels of lipids and energy than wheat, sorghum, and barley (National Research Council et al. 1971). The increased area of harvested corn likely attracted a higher proportion of the population to the S-SJ Delta causing an

increased concentration of cranes there in the 1980s compared to the early 1970s.

Permanent and seasonal wetland habitats in the Central Valley were lost at the rate of 2,100 ha per year between 1954 and 1985 (Frayer et al. 1989). Throughout the Central Valley, meadows and pastures have been converted to croplands (Gilmer et al. 1982). In the Thornton region alone, 900 ha of meadows and native pastures were converted to croplands between 1976 and 1983 (T. Pogson, unpubl. data). Historically, these sites were flooded annually to create waterfowl hunting areas which provided nocturnal roosting sites for cranes (T. Pogson, unpubl. data; C. D. Littlefield, pers. comm.). Most locations converted to croplands in the Thornton region were still being flooded in 1983–1984 and 1984–1985 to create waterfowl hunting areas and were still used by sandhill cranes as nocturnal roosting sites and diurnal loafing areas. In other areas of the winter range, however, seasonal wetlands and other uncultivated habitats that previously were flooded to create waterfowl hunting areas have been converted to croplands (Frayer et al. 1989), and are no longer available to wetland species. It is likely that this habitat destruction contributed to the concentration of cranes at Thornton where roosting sites and feeding habitat were abundant during the winters of 1983–1984 and 1984–1985.

In December 1983, we found 1,500 Greater Sandhill Cranes in areas of the winter range not searched by Littlefield and Thompson (1979) but which had been used by cranes for at least 30 years (J. Shanks, J. Mello, F. Pelladini, pers. comm.). These cranes account for most of the remaining difference between the 6,012–6,810 large cranes we estimated in the Central Valley in 1983–1984 and the 2,359–2,553 cranes reported by Littlefield and Thompson (1979) in December 1969, 1970 and 1976. We conducted extensive roadside surveys primarily in the northern portion of the Central Valley during two winters, while Littlefield and Thompson (1979) conducted approximately 16,000 km of roadside surveys in the entire Central Valley, Carrizo Plain, and the Imperial Valley during each of three winters (C. D. Littlefield, pers. comm.). Littlefield and Thompson (1979) did not search the peripheries of the wintering areas, and they did not have the benefit of using radio-tagged cranes to locate cranes in relatively isolated areas. Our interviews with local residents, waterfowl hunters, and wildlife managers near and beyond the limits of the wintering areas allowed us to more accurately delineate the boundaries of the regions used by the population.

ACCURACY OF POPULATION ESTIMATES

Four sources of error may have affected our estimates of the population's size: 1) counting the same individuals more than once within regions, 2) including the same individuals in estimates from more than one region, 3) confusing Lesser Sandhill Cranes with Canadian and Greater Sandhill Cranes during counts, and 4) failing to count all members of the population. Nine radio-tagged cranes changed nocturnal roost sites on 15% of 103 consecutive nights. Although this is a small number of individuals to describe the behavior of the population, the movements of radio-tagged cranes among roosting sites suggest that summing the number of cranes counted at roosting sites on successive days could be a source of error in our estimates. We controlled this source of error by not summing the peak number of cranes from two adjacent count sites when declines in the number of cranes at one site were associated with an increase at the adjacent site. Marked cranes were never observed at more than site while conducting mid-day counts. Because counts were conducted in the Butte Sink before conducting counts at Thornton in October and November 1983, and marked cranes moved south from the Butte Sink to Thornton beginning in November during both years, it is possible that: 1) some individuals were counted in both regions, or 2) that cranes moved out of the count areas and were not detected. If the former was an important source of error, estimates calculated for October (6,012) and November (6,057) should have been higher than the estimate for December (6,617), when counts at Thornton were conducted before the counts in the Butte Sink. Thus, it seems unlikely that counting the same individuals in more than one region was an important source of error in our estimates. We located only 82–86% of the color-banded and radio-tagged cranes known to be alive in both 1983–1984 and 1984–1985, suggesting we may have missed 14–18% of the population by not locating all the sites used by large cranes. Because this is only a crude estimate of the error caused by not locating all wintering sites, we did not expand our estimates to account for the percentage of the population that we may have missed. We

expended less effort searching for and censusing cranes at Pixley NWR, Merced NWR, Modesto and other locations in the San Joaquin Valley than on the S-SJ Delta and the Sacramento Valley. Littlefield and Thompson (1979) found few Greater Sandhill Cranes in the San Joaquin Valley, and our censuses of Lesser Sandhill Cranes there in 1981, 1982, and 1983 revealed few large cranes (T. Pogson, unpubl. data). The reduced effort in the southern Central Valley probably caused underestimation of the number of cranes in these little-used portions of the winter range and a slight underestimation of the population's size.

It is possible that we sometimes misidentified Lesser Sandhill Cranes as "large cranes" (Greater and Canadian Sandhill Cranes) while conducting roost counts at sites where large cranes and Lesser Sandhill Cranes were both present in large numbers. This misidentification would have inflated our regional estimates of the number of large cranes. However, it is equally likely that we incorrectly classified large cranes as Lesser Sandhill Cranes. Although the magnitude of this error is unknown, we do not believe it significantly affected our estimates.

DISTRIBUTION AND IMPORTANT WINTERING SITES

During our surveys, large numbers of cranes were present in the same regions that were heavily used by the population in the late 1960s and mid-1970s (Littlefield and Thompson 1979). The Chico, Butte Sink, Thornton, and Modesto regions were the most important winter areas for the population in 1983–1984 and 1984–1985, as in 1969–1971 and 1976. We, however, detected the movement of 50–60% of the total population from the Butte Sink to Chico and Thornton during November and December (Table 1), which was not detected by Littlefield and Thompson (1979). Residents of the Chico, Butte Sink, and Thornton regions reported that this movement is an annual event (M. Meyers, J. Buress, M. Leighty, and L. Pucci, pers. comm.).

The Thornton area supported the greatest number of large cranes among regions in the Central Valley. Use of the Thornton area by 5,000–6,000 Lesser Sandhill Cranes (T. Pogson, unpubl. data), in addition the the 1,772–3,829 large cranes (Table 1), was probably related to the availability of waste corn, the dominant crop in this region. The Sacramento Valley, where rice is the dominant cereal grain crop (California Dep. Water Res., unpubl.) hosts only 1,500–2,000 Lesser Sandhill Cranes (T. Pogson, unpubl. data), and overall use of that geographic area by large cranes was lower than use of the Thornton region (Table 1). The Cosumnes River is not dammed and its floodplain is subject to annual flooding from winter rainfall and snowmelt in late winter. This region provided wetland habitats for large numbers of cranes in both winters after waterfowl hunting clubs were drained in the Thornton region.

The same sites used by the population in the late 1960s and mid-1970s (Littlefield and Thompson 1979), the Llano Seco Rancho southwest of Chico, Gray Lodge WMA in the Butte Sink, the El Dorado Gun Club at Thornton, and the Faith and Mape's Ranches west of Modesto, were still important in 1983–1984 and 1984–1985. The numbers of large cranes using these sites in the late 1960s and mid-1970s were similar to the numbers of cranes using these sites at a comparable time of year during the winter of 1983–1984.

During the winters of 1983–1984 and 1984–1985, 98% of the population's winter range was privately owned. Only 19 km^2 of the winter range (ca. 2%), which included important roosting sites, was managed by state and federal wildlife management agencies as waterfowl hunting areas. The majority of the population used private lands for feeding and roosting. Use of public lands by cranes peaked in October 1983 when 36% of the population roosted at two sites in the Butte Sink, the Bean Patch, and Gray Lodge Wildlife Area (Table 1).

SIGHTINGS OF MARKED CRANES

The movement of marked cranes among regions demonstrated relationships among different portions of the winter range. From November through January marked cranes departed from the Butte Sink and moved north within the Sacramento Valley to Afton and Chico, or south out of the Sacramento Valley to Thornton on the S-SJ Delta. In January and February marked cranes left Thornton and moved to the nearby floodplain of the Cosumnes River. Cranes which were banded at Malheur NWR, in southeastern Oregon, were disproportionately concentrated in the Thornton region, while cranes banded at Sycan Marsh, in southcentral Oregon, were disproportionately concentrated in the Butte Sink (T.

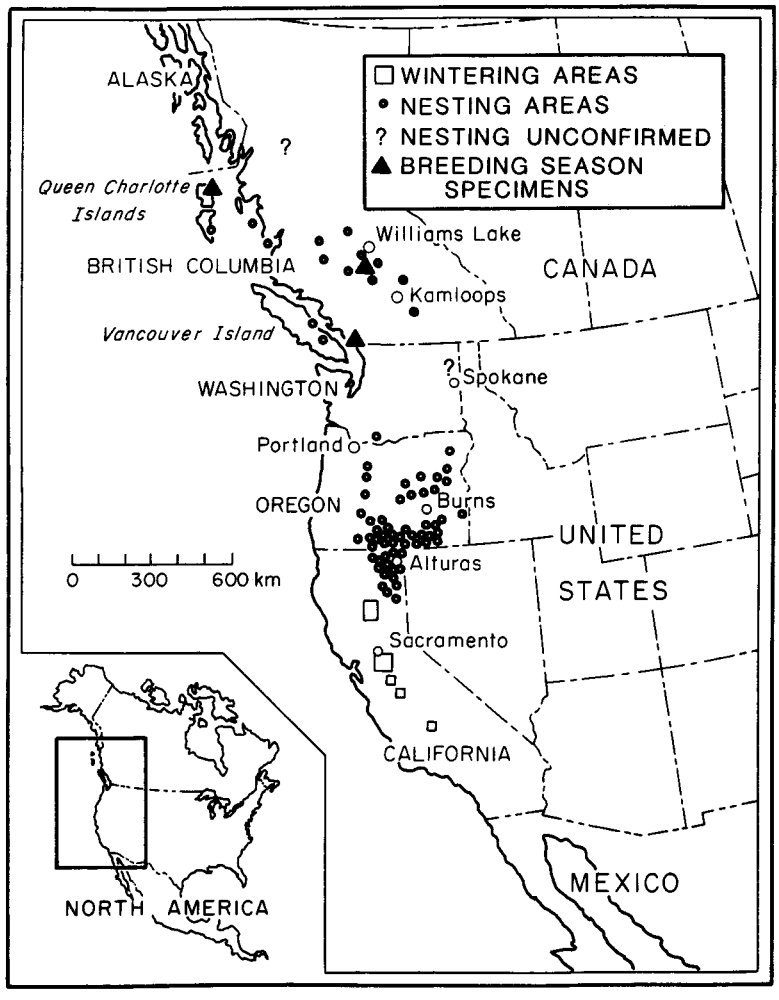

FIGURE 3. Distribution of the Central Valley Population of Sandhill Cranes in the Pacific States and British Columbia.

Pogson, unpubl. data). Because a much larger number of cranes had been banded at Malheur NWR than at Sycan Marsh, there was a disproportionately large number of banded birds observed at Thornton (Table 2).

STATUS OF THE POPULATION

Stern et al. (1987) found that the number of cranes spending the summer in Oregon in 1986 was unchanged from the early 1970s. Between 1971 and 1988 the number of cranes breeding in northeastern California increased from 224 to 340 (52%) (Littlefield 1989); this increase accounts for only a small percentage of the difference between the 6,012–6,810 cranes we estimated were present in the Central Valley in 1983–1984 when compared to the 2,359–2,553 cranes estimated in the mid-1960s and early 1970s (Littlefield and Thompson 1979).

Sightings of banded cranes from Malheur NWR near Kamloops in southern British Columbia, and near Williams Lake in the central part of the province (Fig. 3), confirm that cranes from interior British Columbia use an inland migration route, and indicate that these interior cranes belong to the Central Valley Population (T. Pogson, unpubl. data). The difference between the 6,012–6,852 large cranes we found in California's Cen-

tral Valley during the winter of 1983–1984 and the 3,200–3,400 cranes known to spend the summer in Oregon and California (Stern et al. 1987, Littlefield 1989) provides an estimate of the number of Sandhill Cranes that spend the breeding season in British Columbia, where the number of cranes has been stated to be only 600 (U.S.F.W.S. 1983). Thus, between 2,600–3,600 cranes from British Columbia are wintering in the Central Valley and mixing with the cranes which spend the breeding season in Oregon and California. Hypothetically, an increase in the number of cranes from British Columbia could also have contributed to the increased number of cranes we found in the Central Valley in the 1983–1984 winter.

RACIAL COMPOSITION OF THE POPULATION

The Sandhill Cranes nesting on the coast of British Columbia (Fig. 3) are intermediate-sized birds in the size range of Canadian Sandhill Cranes, *G. c. rowani,* and available data suggest the cranes from the interior of the province are Greater Sandhill Cranes. Cranes from interior and coastal British Columbia use different migration routes, although cranes from both breeding areas winter in the Central Valley (Littlefield and Thompson, 1979, U.S.F.W.S. 1983). The largest number of intermediate-sized cranes counted at wintering areas was only 258 (T. Pogson, unpubl. data), but 893 intermediate-sized cranes were counted at a spring staging area for cranes using the coastal migration route on Sauvies Island north of Portland, Oregon, in 1982 (T. Pogson, unpubl. data). Thus, our estimates of the Central Valley Population's size could have included as many as 893 intermediate-sized cranes from coastal nesting areas of British Columbia.

Winter surveys were valuable for identifying important wintering sites for the protection and acquisition of habitat in the Central Valley. However, because cranes from different breeding ranges appeared to be mixing at wintering areas, winter surveys were not useful for estimating the abundance and productivity of specific breeding subpopulations of cranes from California, Oregon, and British Columbia. Alternatively, it would be useful to census the population and obtain estimates of productivity on the breeding grounds (Stern et al. 1987, Littlefield 1989), or at staging areas in the fall where cranes from particular nesting areas concentrate before moving to more southerly staging and wintering areas (U.S.F.W.S. 1982b). Unfortunately, the post-breeding movements of specific nesting subpopulations of cranes from the Pacific States and British Columbia are poorly known, as is the nesting distribution of cranes in British Columbia. Color-marking, radio-tagging, and monitoring cranes of known breeding origin will be necessary to describe the migration routes, spring and fall staging areas, and wintering areas of cranes from specific breeding subpopulations. Studies of cranes in British Columbia and a marking program throughout the population's breeding range are needed before estimates of production and population size for specific breeding populations can be implemented at wintering areas.

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