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HISTORIC AND RECENT WINTER SANDHILL CRANE DISTRIBUTION IN CALIFORNIA

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Abstract: Understanding the geographic distribution and long-term dynamics of winter foraging areas and night roost sites of sandhill cranes (*Grus canadensis*) is important to their conservation and management. We studied sandhill crane distribution in California's Central Valley from December 2012 through February 2013. We mapped observed flock and night roost locations. Flock locations occurred between Tehama County in the north and Kern County in the south. Flocks were concentrated in the northern Sacramento Valley, the Sacramento-San Joaquin Delta, the northern San Joaquin Valley south of Tracy to Mendota (including the lower Stanislaus and Tuolumne River floodplains and the Grasslands Region), and the southern San Joaquin Valley in the vicinity of Pixley in Tulare County. We also reviewed records of historic occurrences of cranes in California to interpret the importance of our flock and night roost locations. Although cranes wintered in the Los Angeles, San Diego, and San Francisco Bay metropolitan areas in the 19th and early 20th centuries, they no longer occur in significant numbers in these areas due to widespread habitat loss. Three additional areas which were used in the mid-20th century have apparently been abandoned or are being used only infrequently: the Red Bluff area (along the Sacramento River between Red Bluff and Anderson, Tehama County), the Goose Lake area (Kern County), and the Carrizo Plain (San Luis Obispo County). The primary cause of site abandonment at these sites is loss of suitable foraging habitat (small grain crops). With the exception of the Southern San Joaquin region, crane winter range has expanded in the Central Valley since the 1960s. Range expansion has principally been due to expansion of public wildlife refuges and private sanctuaries, plus improvements in their management (including reductions in hunting disturbance). To improve habitat conditions for cranes across their Central Valley wintering range, we recommend that management be focused on protection, enhancement, and creation of crane habitat complexes, each of which should contain 1 or more roost sites surrounded by sufficient well-managed foraging habitat. The following conservation strategies (listed in order of priority) should be implemented for each major crane wintering region: 1) protect existing, unprotected roost sites by fee-title acquisition or conservation easements (prioritize among sites according to their importance to greater sandhill cranes; *G. c. tabida*); 2) protect foraging landscapes around existing roosts, primarily through easements restricting development and crop types that are incompatible to cranes; 3) enhance food availability within those landscapes by improving foraging conditions on conservation lands and providing annual incentives for improvements on private lands; and 4) create additional protected roost sites toward the edge of their existing range where birds can access additional foraging areas.

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Key words: California, Central Valley, *Grus canadensis*, landscape units, Pacific Flyway, population status, sandhill crane, winter distribution.

California is an important wintering region for 3 migratory subspecies and 3 recognized populations of sandhill cranes (*Grus canadensis*), including greater sandhill cranes (*G. c. tabida*, hereafter, greater) of the Central Valley (CVP; Pacific Flyway Council 1995) and Lower Colorado River Valley populations (LCRVP; Pacific Flyway Council 1997), lesser sandhill cranes (*G. c. canadensis*, hereafter, lessers) of the Pacific Flyway Population (PFP; Pacific Flyway Council 1983), and Canadian sandhill cranes (*G. c. rowani*, hereafter Canadians), which have not been designated as a population (Ivey et al. 2005). The CVP, PFP, and the Canadians winter in the Central Valley and the LCRVP winters in the vicinity of the south end of Salton Sea and along the lower Colorado River in California and

Arizona. Greater, which are listed as threatened in California (California Department of Fish and Wildlife [CDFW] 2013), are a priority for conservation actions, while lessers are considered a California Species of Conservation Concern (Littlefield 2008). Understanding the geographic distribution and dynamics of sandhill crane foraging areas and night roost sites is important to the conservation and management of their populations. By comparing past and current distributions we cannot only set current population status in an historic context, but can also better understand tolerances of the species to habitat alterations. This is useful for characterizing current threats and informing the development of conservation strategies.

Historic sandhill crane records in California suggest

a much wider distribution than has been observed since the 1950s. Crane numbers were severely reduced by the early 20th century due to widespread habitat destruction concurrent with human settlement and, perhaps more importantly, unregulated hunting which continued until passage of the federal Migratory Bird Treaty Act in 1916 (Meine and Archibald 1996, Littlefield and Ivey 2002). For greater, historic records collected outside the Central Valley include observations from the southern end of the Salton Sea, Imperial County in southeastern California (Abbott 1940), and from a bird collected along the Colorado River in 1857 or 1858 (Grinnell *et al.* 1918). Greater still occur in these latter 2 areas and are members of the LCRVP. Greater were formerly reported to be present in southwestern California during migration and occasionally in winter, as they were intermittently seen in Ventura and Los Angeles Counties; however, there is some uncertainty about these records because no specimens were collected (Willet 1933).

Within the Central Valley, crane flocks including both greater and lesser were reported in the “Fresno District” (Fresno County) defined as the valley floor between Firebaugh and Wheatland on the west, and between Friant and Reedley on the east (Tyler 1913). Museum specimens of greater were collected near Gridley, Butte County, in 1924, from the Butte Creek Basin, near Colusa, Colusa County, in 1923 and 1924, from 9.6 km west of Pennington, Sutter County, in 1936 (Grinnell and Miller 1944), from Los Banos, Merced County, in 1898 and 1909 (Mailliard 1921), and from Corcoran, Kings County, in 1918 (Swarth 1919).

Fossils of lesser were reported from Rancho La Brea in Los Angeles County (Miller 1912) and McKittrick in Kern County (Miller 1925). In addition, 1,000-5,000-year-old sandhill crane bones were found in Indian middens near Emeryville, Alameda County (Howard 1929). Historic records report that lesser ranged as far south as San Diego (Grinnell *et al.* 1918) along the southern California Coast and near Pasadena (Willet 1912). Museum specimens were collected from Mission San Rafael, Marin County, and Yerba Buena (now San Francisco), San Francisco County (Buturlin 1907), and in the San Francisco Bay area (Grinnell and Wythe 1927) in the 1840s, near Riverside in 1893 (Willet 1912), and near Newport, Orange County, about 1897 (Grinnell 1909). Specimens were also collected from Los Angeles County in 1904 (2 birds; Grinnell 1909) and 1918 (Wyman 1919), near Long

Beach in 1912 (Willet 1912), and near Culver City in 1929 (Willet 1933). Lesser were also historically reported as moderately common near the Salton Sea, in the Imperial Valley, and also the Colorado River Valley (Abbott 1940, Grinnell and Miller 1944).

Museum specimens of lesser within the Central Valley include 2 without collection dates, 2 collected in 1897, and an additional 6 collected in 1909 from Merced County (Mailliard 1911, 1921), plus 1 collected in 1918 from Corcoran, Kings County (Swarth 1919). Flocks of lesser were reported in 1880-81 near Stockton, San Joaquin County; in 1884 near Marysville, Yuba County, and Gridley and Chico, Butte County; in 1914 near Lathrop, San Joaquin County; in 1918 near Los Banos (Grinnell *et al.* 1918); and in 1929 near Firebaugh and Mendota, Fresno County (McLean 1930).

There have only been a few studies and reports that provide specific information on sandhill crane distribution in the Central Valley since the 1960s. Their distribution in the Sacramento-San Joaquin Delta region (hereafter, Delta) was described in a report by Zeiner (1965). Distribution of lesser was studied by Pogson and Kincheloe (1981) and Littlefield and Thompson (1982). Studies of greater were conducted throughout the Central Valley in the 1970s (Littlefield and Thompson 1979), mid-1980s (Pogson and Lindstedt 1991), and early 1990s (Littlefield 1992). Additionally, in 2005 the U.S. Fish and Wildlife Service (USFWS) developed a map depicting crane distribution in the Sacramento Valley (USFWS, unpublished data). More recently, an extensive study was conducted of sandhill crane distribution in the Delta region (Ivey *et al.* 2014). Our objective of this paper is to synthesize historic and current information to illustrate changes in crane distribution in the Central Valley of California to provide a comprehensive compilation of sandhill crane winter distribution patterns and to inform conservation planning for wintering cranes.

STUDY AREA

Our review of historic crane distribution during winter included all historic wintering sites in California, including the Central Valley, the San Francisco Bay region, the Los Angeles Basin, the San Diego region, and the Imperial Valley. Our field survey area encompassed major crane wintering regions in the Central Valley, approximately 700 km in length and 100 km wide (Figure 1). The major sandhill crane wintering

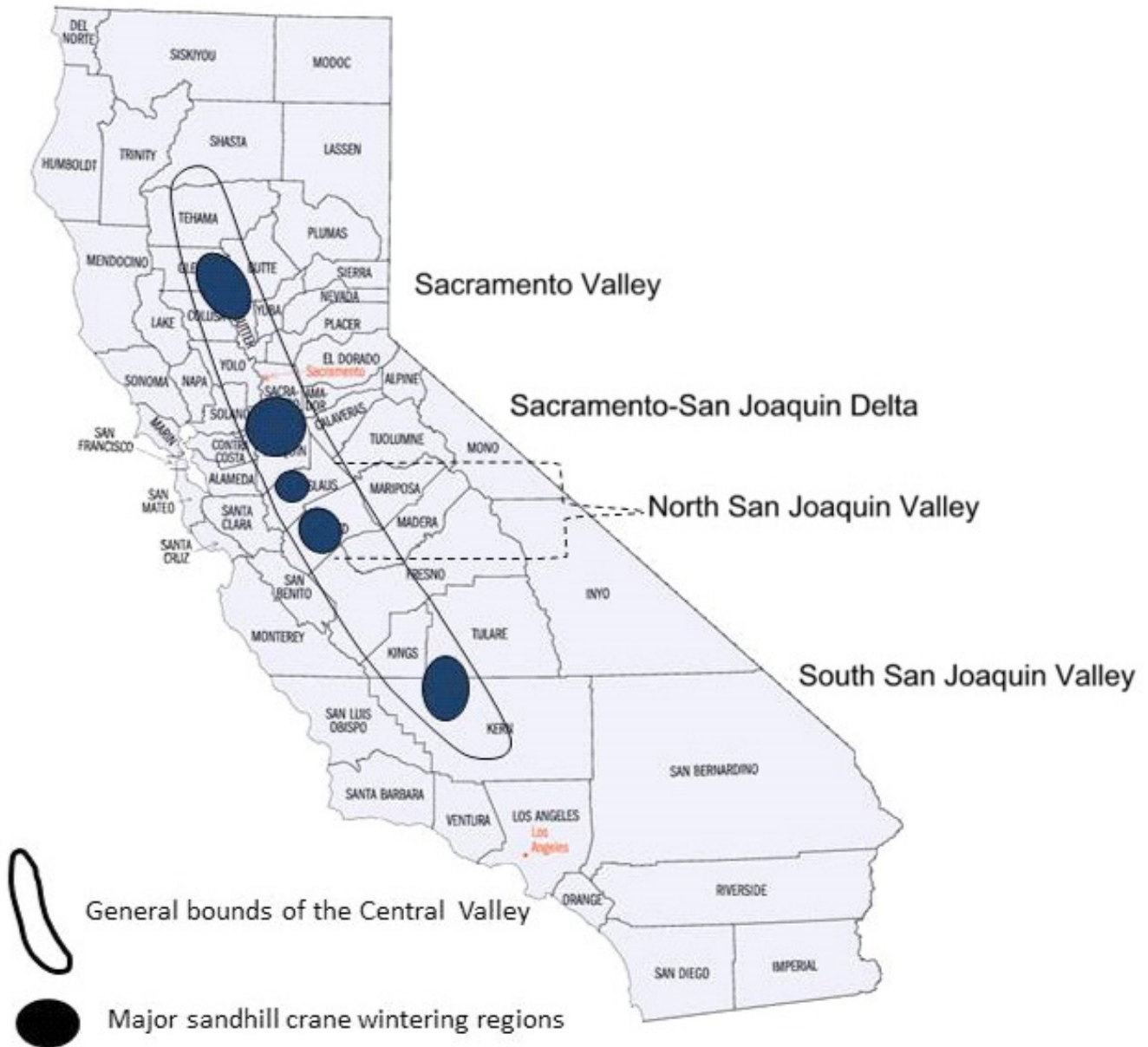


Figure 1. Central Valley of California study area with approximate locations of the Central Valley (black line) and major wintering areas of sandhill cranes.

areas in this study area include: the Sacramento Valley rice-growing region from Chico and Red Bluff, south to Williams and Marysville; the Sacramento-San Joaquin Delta (including the Cosumnes River Floodplain and the Delta region from Freeport south to Highway 4 west of Stockton); the North San Joaquin Valley south of Tracy to Mendota, including the lower Stanislaus and Tuolumne River floodplains, San Joaquin River National Wildlife Refuge (NWR) and the Grasslands Ecological

Management Area (Merced County); and the South San Joaquin Valley south of Visalia to Bakersfield, especially around Pixley NWR. Additionally, sandhill cranes still occasionally use areas along the Sacramento River floodplain between Red Bluff and Anderson in Tehama County, the Mendota area in Fresno County, the eastern foothills of Merced and Stanislaus Counties, the Goose Lake area in Kern County, and Soda Lake on Carrizo Plain in San Luis Obispo County.

METHODS

Mapping Current Foraging and Roosting Sites

Sandhill crane winter foraging flock surveys were conducted from December 2012 through February 2013 on private lands in the Central Valley of California. Surveys were conducted by driving public roads and mapping flocks visible during daylight hours. Field work focused on identifying foraging sites during morning and evening foraging times, but we also recorded locations of roost sites. We used binoculars and spotting scopes to locate flocks and count flock sizes. In addition, we included 2012-13 reports of flocks on the ground from eBird (Sullivan et al. 2009) in our dataset. These locations and associated flock sizes were used to create a GIS layer using ArcGIS version 10.1 (Environmental Systems Resource Institute, Redlands, California). We focused our survey efforts on 5 Central Valley wintering regions to define the bounds of the sandhill crane winter ranges in these areas (Figure 1): 1) the Sacramento Valley between Marysville and Chico; 2) Sacramento-San Joaquin Delta; 3) lower Stanislaus-Tuolumne-San Joaquin rivers floodplains (San Joaquin River NWR area); 4) Grasslands Region; and 5) southern San Joaquin Valley (Pixley NWR area). We spent less survey effort in the Delta than in other regions, because sandhill crane winter range was recently defined there (Ivey et al. 2014). Flock and roost site locations were plotted using ArcGIS version 10.1. In addition to roost sites mapped in 2012-13, we also included roost sites identified during recent studies (Ivey and Herziger 2003, Shaskey 2012, Ivey et al. 2014).

Historic Sandhill Crane Habitat Use Patterns

We synthesized available geo-referenced historic flock location data in the Central Valley (none was obtained for the southern San Joaquin Valley). We examined changes in use of roost and foraging locations over time by summarizing available reports (since 1963) from agency files and publications and creating maps of the distribution of those sites using ArcGIS version 10.1 to illustrate changes. We also used mid-winter waterfowl survey data (USFWS 2014) and Audubon Christmas Bird Count (CBC) data (National Audubon Society 2010) to assess changes in crane numbers and distribution.

RESULTS

Current Sandhill Crane Distribution

We mapped 1,858 diurnal sandhill crane flock locations between 9 December 2012 and 3 March 2013. Observed flocks ranged between southern Tehama County in the north and northwest Kern County in the south. As expected, flocks were concentrated in the historically most used areas: the northern Sacramento Valley, the Delta, the northern San Joaquin Valley south of Tracy to Mendota (including the lower Stanislaus and Tuolumne River floodplains, San Joaquin River NWR and the Grasslands Region), and the southern San Joaquin Valley south of Visalia to Bakersfield (primarily Pixley NWR) (Figure 2). We spent less effort in surveys near Red Bluff and the Mendota area (2 mornings each), as we did not locate any sandhill crane flocks when we were there, and available data (eBird and birding sources) suggested sandhill crane use was sporadic at those 2 sites. We did not visit Carrizo Plain, as recent data suggest that sandhill crane use has become very limited in recent years, and we doubt that it will become



Figure 2. Distribution of sandhill crane foraging flocks mapped in December 2012 through February 2013 in the Central Valley of California.

an important sandhill crane area in the future because the area no longer provides grain fields.

From assembled reports, data, and personal communications with knowledgeable individuals, we mapped 121 roost sites that have been recorded since 2002 and classified them as either wetland (typically annually available during winter on the landscape) or cropland (often only temporarily available; Figure 3). These records are incomplete, especially in the Sacramento Valley, where there were numerous temporary roost sites that were used only when rice fields were flooded. Our surveys spanned 10 weeks in late winter and it is likely we missed many temporarily used roost sites.

Changes in Sandhill Crane Use Patterns in the Sacramento Valley Region

Since the mid-1980s study by Pogson and Lindstedt (1991), sandhill crane winter distribution has greatly

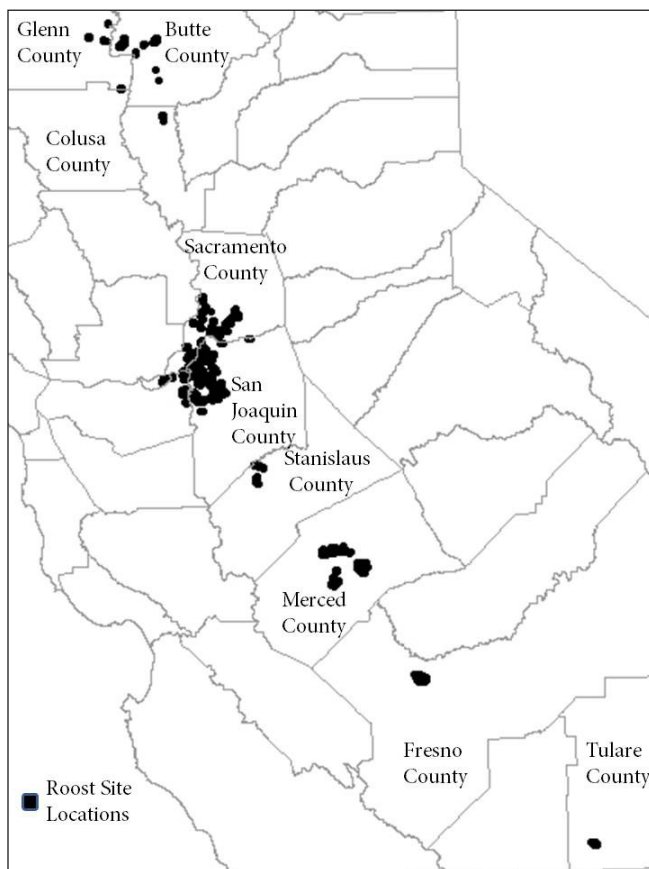


Figure 3. Sandhill crane roost site locations mapped in the Central Valley of California, 2002-2013.

expanded (Figure 4). The winter ranges depicted in Figure 4 should not be considered exact bounds of sandhill crane winter ranges, but rather generalized outside bounds of sandhill crane distribution, subject to the judgment of the individuals who drew them.

Occasional sandhill crane surveys in this region during the winter of 1981-82 revealed that most cranes were using areas surrounding Gray Lodge Wildlife Area and only 1 flock was ever observed west of the Sacramento River during that winter (G. Ivey, personal observation). The wintering region described by Pogson and Lindstedt (1988) showed sandhill cranes limited to 2 major areas in the mid-1980s, the Upper Butte Basin and the Butte Sink (Figure 4A). West of the Sacramento River, they reported “isolated records” of sandhill cranes. Sandhill cranes had expanded their range, toward Biggs and Riceton by 1993 (Littlefield 1993; Figure 4B). In 1994, the mid-winter survey recorded 69 sandhill cranes west of the Sacramento River, and since then, sandhill cranes have been regularly recorded there on those surveys; increasing to a peak of 2,259 in 2014 (USFWS 2014). By 2005, the winter range of sandhill cranes had expanded west of the Sacramento River, using areas west of Interstate 5 between Williams and Maxwell and around Delevan NWR (Sacramento NWR files, map dated 2005; Figure 4C). During our study, we found sandhill cranes had further expanded their use areas toward Live Oak and Sutter, around Colusa NWR, and toward Willows and Hamilton City (Figure 4D). Our foraging flock surveys documented the largest concentrations of sandhill cranes in the Willows-Bayliss-Hamilton City and the Rancho Llano Seco-Rancho Esquon areas.

East of the Sacramento River, some sites show reduced use by sandhill cranes, apparently due to conversion of former pastures and rice fields that had been used by foraging sandhill cranes to wetlands during the establishment of Upper Butte Basin Wildlife Area and Sacramento River NWR. Additionally, sandhill cranes were displaced by increased disturbance associated with waterfowl hunting programs and new duck clubs that were established in that area, causing cranes to shift to other use areas (J. Snowden, personal communication).

Changes in Sandhill Crane Distribution in the Delta Region

In the mid-1960s, the winter range of cranes in the Delta region was relatively small, and spanned



Figure 4. General distribution of wintering sandhill cranes in the Sacramento Valley of California over time; A = 1983-1984 (Pogson and Lindstedt 1988), B = 1991-1993 (Littlefield 1993), C = 2005 (Sacramento National Wildlife Refuge files), and D = 2012-13 (this study).

most of the area between the West Fork of the Mokelumne River at Staten Island and Interstate 5 to the south, including most of Terminous Tract, and all of Brack, Canal Ranch, and New Hope Tracts. Also included were areas west of Interstate 5, south of the Cosumnes River channel to about 3.2 km west of Galt, and south to the Mokelumne River channel, including the fields about 1.6 km south of Thornton (Zeiner 1965; Figure 5A), while the greatest concentration of cranes was centered

on what is now the North Isenberg Sandhill Crane Reserve. Pogson and Lindstedt (1988) mapped Delta sandhill crane winter range, which included Tyler and Grand Island, and a few isolated locations south of Highway 12 (Figure 5B). They noted a couple of large roost sites on the Cosumnes River Floodplain, which are now within the Cosumnes River Preserve, 4 roost sites on Brack Tract, 1 on Canal Ranch, 3 on Staten Island, 3 on Tyler Island and 1 on Grand Island. These additional roost sites that Pogson and

Lindstedt (1988) identified likely allowed sandhill cranes to expand their wintering range.

An extensive study of the Delta region during 2006-2009 (Ivey et al. 2014) and our 2012-13 surveys documented a much broader winter range (Figure 5C), indicating that sandhill cranes have expanded their range north to Stone Lakes NWR and vicinity, east of Highway 99 on the Cosumnes River and Dry Creek floodplains, and further west and south in the Delta. This was likely due to an expanded number and distribution of roost sites, as Ivey et al. (2014) documented 69 roost sites, about half of which were in flooded croplands.

The establishment of protected areas providing roost sites since the mid-1980s, plus an apparent increase in farming practices using winter flooding as a management tool to facilitate stubble decomposition and reduce soil salts and weeds, has apparently contributed to this broader distribution of sandhill cranes in the

Delta (Ivey et al. 2003). The El Dorado and Robin Bell gun clubs on Brack Tract were purchased in 1985 by CDFW to provide secure greater sandhill crane roosts on Brack Tract. Originally designated as Woodbridge Ecological Reserve, these 2 sites were renamed the Isenberg Sandhill Crane Reserve. Cosumnes River Preserve (CRP) was established in 1987 and has grown to over 20,000 ha, including the 3,700-ha Staten Island which was added in 2002. This preserve is managed under a broad partnership with The Nature Conservancy (TNC), Bureau of Land Management (BLM), CDFW, Sacramento County, California Department of Water Resources, Ducks Unlimited, and the California State Lands Commission. In 1994, the Stone Lakes NWR was established by USFWS. However, since early 1990s, approximately one-third of the winter range mapped in Figure 5C has been lost following conversion to orchards, vineyards, and in some cases, turf farms, blueberries, and more recently, solar farms (G. Ivey, personal observation). Such losses of foraging habitat may be contributing toward the winter range expansion we have documented.

Changes in the San Joaquin River NWR Region

In this region, the sandhill crane winter range, including 4 roost sites, was mapped by Pogson and Lindstedt (1988; Figure 6A). San Joaquin River NWR was established in 1997 and the USFWS subsequently acquired easements on several important properties, including large portions of the Faith and Mapes Ranches. As a result, sandhill crane winter range expanded (Figure 6B), likely because of increased security at roost sites and also the provisioning of a large roost site on the refuge, south of Highway 132 (White Lake). However, many of the croplands in this region have been converted to orchards and urban expansion from Salida and Modesto has reduced available habitat on the east side of this wintering area (G. Ivey, personal observation).

Changes in Sandhill Crane Use Patterns in the Grasslands Region

Historic maps of sandhill crane winter range for this region were not available. However, there has been significant expansion of conservation properties in the vicinity of the refuges here since the late 1970s. The Grasslands Wildlife Management Area (GWMA) is a

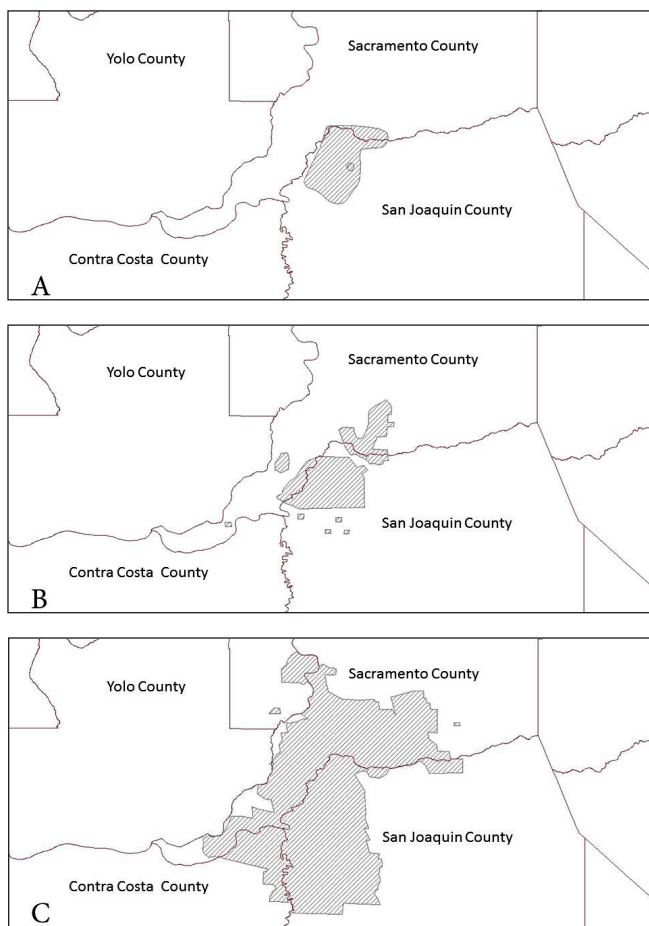


Figure 5. General distribution of wintering sandhill cranes in the Sacramento-San Joaquin Delta region of California. A = 1963-1965, B = 1983-1984, and C = 2006-2013.

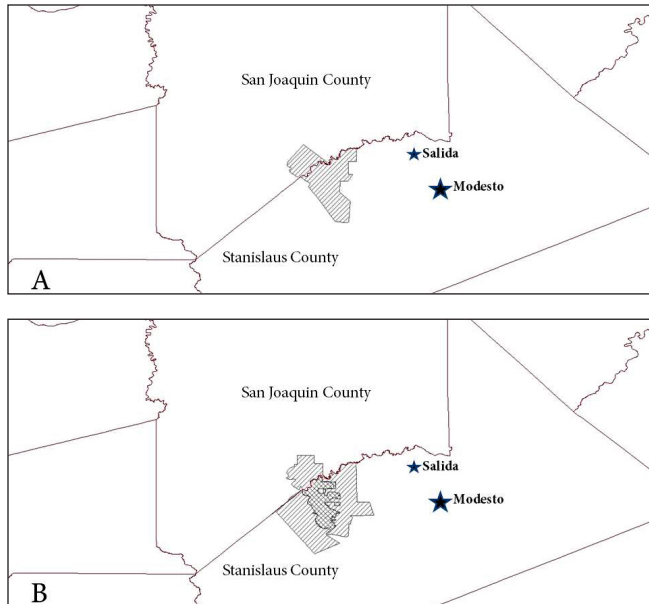


Figure 6. General distribution of wintering sandhill cranes in the San Joaquin River National Wildlife Refuge area of California. A = 1983-1984 (Pogson and Lindstedt 1988), and B = 2006-2013 (Ivey et al. 2014, this study; central cross-hatched area = San Joaquin River National Wildlife Refuge).

USFWS block of conservation easements on private lands that was initiated in 1979, which currently encompasses over 32,000 ha. However, because much of the GWMA is comprised of duck hunting clubs, use by sandhill cranes on those properties is very limited. Areas within the GWMA that are east of Highway 165 are within the current sandhill crane winter range. Also, the Arena Plains Unit of the Merced NWR was established in 1992. Expansion of these conservation areas has provided additional secure sandhill crane roost sites. However, orchards are encroaching into this range around Stevinson, Merced, and El Nido (G. Ivey, personal observation). Figure 7 illustrates the current sandhill crane winter range in the Grasslands region, interpreted from our flock surveys and other recent data.

Changes in Sandhill Crane Use Patterns in the Southern San Joaquin Valley Region

Historic maps of sandhill crane winter range for this region were not available. Therefore, our 2013 flock surveys represent the first intensive surveys of the sandhill crane winter range in this region. Only 8 lessers were reported at Pixley NWR in 1969 (established in

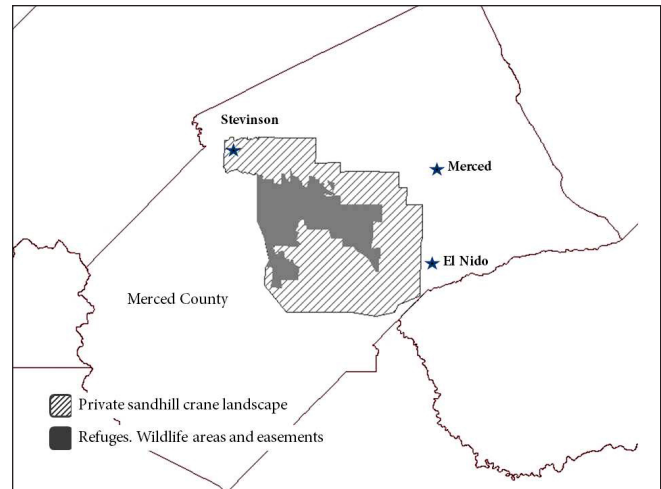


Figure 7. General distribution of wintering sandhill cranes in the Grasslands Region in 2013, Merced County, California.

1959) and a peak of 628 lessers was reported in 1970 at Goose Lake in Kern County (Littlefield and Thompson 1982). A 1979 aerial survey recorded 2,050 sandhill cranes at Goose Lake (Kern NWR, unpublished data), while Pogson and Kincheloe (1981) found 1,500 lessers there in 1981. Since those early investigations, sandhill crane numbers have apparently greatly increased at Pixley NWR and decreased at Goose Lake. Since 2000, numbers have reached peaks of over 9,400 roosting at Pixley NWR (Kern NWR, unpublished data). We found no sandhill cranes during our flock surveys in the Goose Lake area during January or February, 2013. However, flocks of 78 and 320 were observed there in October in 2013 and 2015, respectively (D. Hardt, personal observation). Our map of the current sandhill crane winter range is displayed in Figure 8. We note that orchards are also encroaching, primarily into the east side of this range, near the town of Pixley (G. Ivey, personal observation).

Areas of Former Importance

Carrizo Plain.—This site was formerly important primarily to lessers, as 3,200 were reported there in 1947 (Walkinshaw 1973) and an estimated 10,000-14,000 sandhill cranes were observed there in the 1960s (McCaskie 1967). More recently, this site has received little sandhill crane use. This reduced use has occurred since acquisition of Soda Lake by TNC and the BLM in 1988 and eventual designation of Carrizo Plain as a National Monument in 2001. CBC data provide an

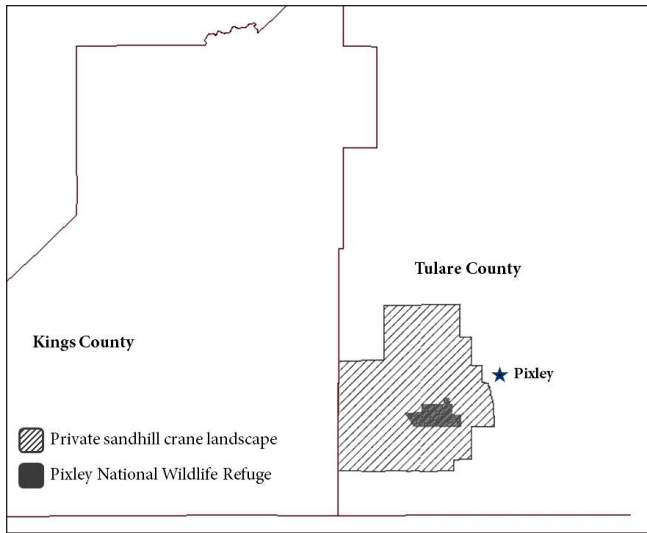


Figure 8. General distribution of wintering sandhill cranes in the Pixley National Wildlife Refuge Region in 2013, Tulare County, California.

assessment of the reduction in numbers at this site (Figure 9). The decline is probably due to the elimination of 16,000 ha of grain crops that were cultivated within the Monument prior to the acquisitions as well as the overall decline of cultivated grain fields in the valley and the foothills adjacent to the Monument (BLM 2010). It is not likely that this area will recover its former importance to cranes given that the Monument is now managed primarily for threatened and endangered arid upland wildlife species and because of the paucity of grain-farming elsewhere in the region.

Red Bluff.—This site is in the vicinity of Jellys Ferry, between Anderson and Red Bluff, along the Sacramento River. In 1970, 1,400 lessers were reported here (Littlefield and Thompson 1982). Another report states that up to 500 sandhill cranes were observed in this location in the 1970s and 1980s (Pogson and Kincheloe 1981), with birds roosting in the Table Mountain area and foraging north to the Anderson Bottoms and south to the Antelope Creek and Cond Ranch area (Littlefield 2008). However, sandhill crane use here has diminished since the early 1990s, for reasons unknown, as evidenced by CBC data which last recorded sandhill cranes in 1991 (Figure 10). Yet cranes have been reported here in more recent years (B. Deuel, personal communication; eBird data). Most recent sightings are relatively small flocks observed in late February or early March, during the period when sandhill cranes begin moving north, so

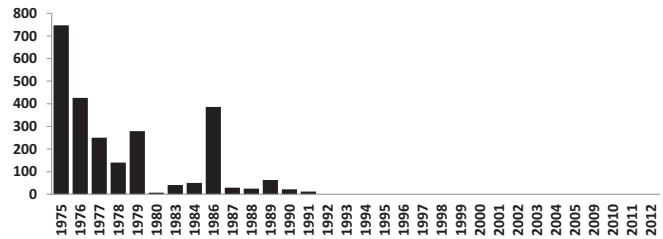


Figure 9. Numbers of sandhill cranes recorded on the Carrizo Plain Christmas Bird Count, California, 1970–2012.

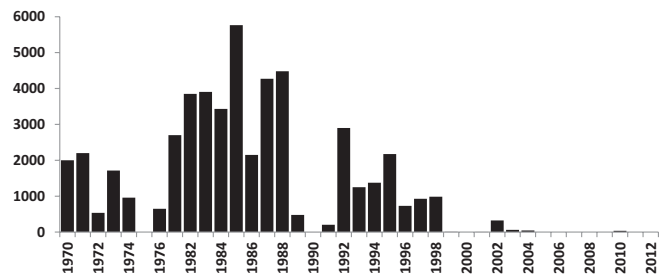


Figure 10. Numbers of sandhill cranes recorded on the Red Bluff Christmas Bird Count, California, 1975–2012.

the area apparently serves as a stop-over site for some spring migrants.

DISCUSSION

The Central Valley is the most important sandhill crane wintering area in the Pacific Flyway. Although this paper provides evidence for winter range expansion and an increasing population trend for sandhill cranes wintering in the valley, it is important to understand that cranes only use a small percentage of the available agricultural landscape. Given their strong fidelity to wintering sites (Ivey et al. 2015), continued loss of foraging habitats within their current range may reduce resources needed to support the size of the population. Therefore, it is important to focus activities on maintenance of suitable landscapes in this important sandhill crane wintering area.

The Sacramento Valley region is of particular importance to greater (G. Ivey, unpublished data). In the early 1980s, undisturbed, secure night roost habitat was the significant limiting factor for sandhill cranes in that region (J. Snowden, personal communication), and we believe that this limitation contributed to the smaller winter sandhill crane landscape during that

time. Legislation in 1991 (Connelly-Areias-Chandler Rice Straw Burning Reduction Act: AB 1378, Ch. 787, 1991) limited burning of rice stubble and resulted in greatly increasing the practice of flooding to decompose stubble (Miller *et al.* 2010). We believe this change allowed sandhill cranes to extend their winter range considerably in that region. Also, sandhill crane numbers have increased in the Sacramento Valley, as evidenced by the increasing trend of mid-winter survey numbers (USFWS, unpublished data), which likely has contributed to their range expansion there. However, even though there are extensive areas of flooded rice for sandhill cranes to choose from, most flooded rice fields are subject to disturbance from waterfowl hunting (Fleskes *et al.* 2005) and the majority are managed at water levels too deep to provide ideal roost site conditions (Shaskey 2012). It is likely that there is lower hunting pressure on private lands where we found concentrations of sandhill cranes during this study, leading to lower disturbance. Reduced disturbance due to hunting should allow more successful conservation of sandhill cranes in these areas.

Two necessary components of sandhill crane winter range include: 1) suitable, undisturbed roost sites, and 2) sufficient nearby foraging habitat (Ivey *et al.* 2014). A secure roost site is critical to sandhill crane wintering range because this dictates access to available foraging habitats. Without it, the birds will abandon those landscapes. Additionally, greater in the CVP are very loyal to their wintering site, which makes them less adaptable to change compared to lessers (Ivey *et al.* 2015). Therefore, conservation of roost sites of greater should be a priority. Because of energetic costs, foraging sites close to roost sites are more important to cranes than foraging sites more distant.

A suitable roost site and the associated foraging areas radiating out to a certain distance from the roost form a conceptual framework for thinking about “landscape units” as a basis for sandhill crane conservation (Ivey *et al.* 2015). The scale of effective conservation planning differs by subspecies. For greater, focusing on a conservation radius within 5 km of a known roost was recommended. This radius encompassed 90% of the foraging flights made by greater. For lessers, a conservation radius of 10 km was recommended (90% of their flights; Ivey *et al.* 2015). Ivey *et al.* (2015) recommended that management, mitigation, acquisition, easement, planning, and farm

subsidy programs intended to benefit sandhill cranes will be most effective when applied at those scales, and that conservation and management of wintering habitats should include creating both new roost and feeding areas within these radii to ensure high chances of successful use. Developing new roost sites toward the edge of these crane landscape units will allow sandhill cranes access to additional agricultural fields and increase their winter range carrying capacity (Ivey *et al.* 2015).

In the Delta and San Joaquin Valley regions, most of the important roost sites are protected, as they occur on NWRs, state wildlife areas, and natural area preserves and conservation easement lands. In contrast, in the Sacramento Valley region, most existing roost sites currently occur on private lands where they are susceptible to conversion to unsuitable crops, incompatible farming practices (e.g., deep flooding), increased disturbance, and loss of irrigation water that prevents crop production and/or post-harvest flooding (i.e., due to drought). In addition, in all Central Valley sandhill crane wintering regions, their foraging areas are primarily on private lands (Littlefield 2002, Ivey and Herziger 2003, Shaskey 2012). These private lands are subject to loss from urbanization and conversion to incompatible crops, and also are not typically managed to optimize food availability to sandhill cranes. Habitat changes that occur on privately owned fields within the daily flight radius of a sandhill crane may change crane abundance at a roost, regardless of management actions at the roost site itself.

Existing wintering sites are threatened by habitat loss, which is occurring throughout the Central Valley. Habitat losses are primarily due to conversion of private lands to incompatible crop types (e.g., vineyards and orchards) as well as expanding urbanization (Littlefield 2002, Ivey *et al.* 2015). In the Delta, sea level rise may destroy significant areas of sandhill crane wintering habitat in the future, and generally the effects of climate change may limit future water supplies to critical sandhill crane roost sites throughout the valley. Other threats to sandhill crane habitat include development projects such as new water delivery systems and solar farms and the associated powerlines that serve them. Excessive disturbance (primarily from waterfowl hunting) can also reduce habitat availability to sandhill cranes. Additionally, some sandhill crane foraging habitat loss has occurred due to riparian forest and shrub plantings.

MANAGEMENT IMPLICATIONS

We recommend the following conservation strategies (listed in priority order) be implemented to maintain crane use in each major sandhill crane wintering region: 1) protect existing, unprotected roost sites by fee-title acquisition or conservation easements (prioritize by their importance to greater); 2) protect foraging landscapes around existing roosts, primarily through easements restricting incompatible crop types and development; 3) enhance food availability within those landscapes by improving conditions on conservation lands and providing annual incentives for improvements on private lands; and 4) develop additional protected roost sites toward the edge of existing crane use areas to allow sandhill cranes to access additional foraging areas.

Prioritizing Among Wintering Sites

We recommend prioritizing conservation among winter regions based on the relative risk of habitat loss, the relative number of threatened greater present, and the relative number of all sandhill cranes present.

Sandhill crane habitat loss is occurring throughout the Central Valley, primarily due to conversion to incompatible crop types (e.g., vineyards and orchards) as well as expanding urbanization, both of which pose a threat to these populations (Littlefield 2002). Conservation and management of wetlands and agricultural areas within Central Valley crane wintering regions is important. Although we are not aware of any

detailed analyses of habitat loss for sandhill cranes, the Delta is certainly under the greatest threat due to pressures from expanding urban areas and is losing habitat to incompatible permanent crops faster than other regions (Central Valley Joint Venture 2006). Also, this region has the threat of sea level rise (which will likely eliminate many of the Delta Islands).

We recommend that conservation priority be geared toward the Delta because habitat loss is highest there and it supports the second highest number of greater and the highest number of sandhills overall (Table 1). Secondly, the Sacramento Valley has the highest number of greater and third highest number of sandhills overall. Therefore, we propose that the major wintering regions be considered in this priority for conservation focus: 1) the Delta, 2) the Sacramento Valley, 3) the Grasslands, 4) the Pixley NWR area, and 4) the San Joaquin River area. However, it would be good to work simultaneously in all 5 of these regions to maintain their value to wintering sandhill cranes and take advantage of conservation opportunities as they become available.

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Table 1. Peak numbers of greater sandhill cranes and all sandhill cranes counted during surveys of the wintering regions of the Central Valley of California, 1970-2014.

Sandhill crane wintering region	Highest estimate of greater sandhill cranes	Highest estimate of all sandhill cranes
Sacramento Valley	6,000 (1991-93) ^a	7,984 (2014) ^b
Sacramento-San Joaquin Delta	5,219 (1983-85) ^c	27,213 (2008) ^d
San Joaquin River NWR	298 (1971) ^e	4,383 (2012) ^f
Grasslands	110 (1971) ^e	15,275 (2010) ^g
Southern San Joaquin Valley	68 (1970) ^e	9,403 (2009) ^h

^a Littlefield (2002).

^b 2014 Mid-winter waterfowl survey (USFWS, unpublished data).

^c Pogson and Lindstedt (1988).

^d Ivey et al. (2014).

^e Littlefield and Thompson (1979).

^f 2012 Christmas Bird Count.

^g San Luis NWR files (USFWS, unpublished data).

^h Pixley NWR files (USFWS, unpublished data).

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