CHARACTERISTICS OF SANDHILL CRANE ROOSTS IN THE SACRAMENTO-SAN JOAQUIN DELTA OF CALIFORNIA

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Abstract: The Sacramento-San Joaquin Delta (Delta) region of California is an important wintering region for 2 subspecies of Pacific Flyway sandhill cranes (*Grus canadensis*): the Central Valley Population of the greater sandhill crane (*G. c. tabida*) and the Pacific Flyway Population of the lesser sandhill crane (*G. c. canadensis*). During the winters of 2007-08 and 2008-09 we conducted roost counts, roadside surveys, aerial surveys, and tracked radio-marked birds to locate and assess important habitats for roosting cranes in the Delta. Of the 69 crane night roosts we identified, 35 were flooded cropland sites and 34 were wetland sites. We found that both larger individual roost sites and larger complexes of roost sites supported larger peak numbers of cranes. Water depth used by roosting cranes averaged 10 cm (range 3-21 cm, mode 7 cm) and was similar between subspecies. We found that cranes avoided sites that were regularly hunted or had high densities of hunting blinds. We suggest that managers could decide on the size of roost sites to provide for a given crane population objective using a ratio of 1.5 cranes/ha. The fact that cranes readily use undisturbed flooded cropland sites makes this a viable option for creation of roost habitat. Because hunting disturbance can limit crane use of roost sites we suggest these 2 uses should not be considered readily compatible. However, if the management objective of an area includes waterfowl hunting, limiting hunting to low blind densities and restricting hunting to early morning may be viable options for creating a crane-compatible waterfowl hunt program.

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Key words: California, *Grus canadensis*, habitat management, hunting disturbance, roost sites, Sacramento-San Joaquin Delta, sandhill crane.

The Sacramento-San Joaquin Delta (hereafter, Delta) is an important wintering region for 2 subspecies of Pacific Flyway sandhill cranes (*Grus canadensis*): the Central Valley Population of the greater sandhill crane (*G. c. tabida*, hereafter, greaters) and the Pacific Flyway Population of the lesser sandhill crane (*G. c. canadensis*, hereafter, lessers) (Pacific Flyway Council 1983, Pacific Flyway Council 1997). Greaters, 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). However, little is known about winter use of roost sites and characteristics of roost sites used by wintering cranes that could aid in designing a biologically sound conservation strategy for cranes in the Delta.

Other than on the Platte River in Nebraska (e.g., Krapu et al. 1984; Norling et al. 1992; Folk and Tacha 1990; Parrish et al. 2001; Davis 2001, 2003), little work has been done to quantify habitat types used by roosting cranes. In the Platte River system, cranes roost in the shallow waters (1-21 cm) and sandbar islands within the river channel. While the water depth information likely has broad applicability, other habitat characteristics of the North Platte River are not found in California. Additionally, there are no published studies about the suitability of flooded agricultural fields as roost sites for cranes or information that quantifies how roost site size correlates with crane abundance at the roost. In this study, we characterize the features of crane roosts at both the individual site and roost complex scales, correlate roost abundance with roost size, and correlate roost use with recreational waterfowl hunting activity to increase our understanding of crane roosting ecology and support crane habitat conservation and management.

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STUDY AREA

We centered our study on several properties in the Delta that are specifically managed to provide night roost sites for cranes, and which subsequently support most of the cranes that winter in the region (Pogson and Lindstedt 1991, Ivey and Herziger 2003, U.S. Fish and Wildlife Service 2007), including Cosumnes River Preserve, Staten Island and adjacent Canal Ranch and Bract Tracts (which includes the Isenberg Crane Reserve), and Stone Lakes National Wildlife Refuge (NWR) (Fig. 1). The Delta region is primarily rural agricultural landscapes bordered by urban communities. Agricultural land uses include field and silage corn, fall-planted wheat, rice, alfalfa, irrigated pasture, dairies, vineyards, and orchards. The region also contains large tracts of oak savannah and floodplain wetlands along the Cosumnes and Mokelumne river floodplains.

We trapped cranes at Cosumnes River Preserve and Staten Island. The Cosumnes River Preserve (9,915 ha within our study area) was established by The Nature Conservancy (TNC) and is a conglomeration of lands owned or under conservation easements by TNC and its agency partners. It provides habitats for cranes including seasonal wetland roost sites, oak savannahs, organic rice, and other crops. Staten Island (3,725 ha) was a large corporate farm that was purchased by TNC and was managed as an income-producing farm but with a focus on providing habitat for cranes and other wildlife and developing wildlife-friendly farming practices that can serve as a demonstration to other farmers in the region (Ivey et al. 2003). Cranes use roosts at Staten Island and adjacent Canal Ranch and Brack Tracts as a complex. We define a complex as an association of flooded fields and wetlands in close proximity to each other (none > 1 km from another flooded site). Brack Tract contains Isenberg Crane Reserve, owned and managed by the California Department of Fish and Wildlife, and consisted of 2 seasonal wetland sites (totaling 60 ha) that were surrounded by private agricultural lands, including a large area of flooded rice fields that also provided roosts. Stone Lakes NWR has developed 410 ha of seasonal wetland sites that were used as night roosts and which were also adjacent to private agricultural lands. The refuge also managed croplands such as irrigated pasture, alfalfa, and occasionally grain crops for cranes and other wildlife.

METHODS

We defined a roost as a site used by cranes at night. We cataloged locations of sandhill crane roost sites in the Delta during 2007-08 and 2008-09 by tracking radio-tagged cranes and through observations from the ground. We captured and radio-tagged a total of 77 sandhill cranes during 17 October 2007 and 27 February 2008 in the Delta, and during April and August 2008 at northern breeding and staging areas before they returned to the Delta (see Ivey et al. 2014 for detailed methods of crane capture, handling, and tracking). Our handling of cranes was conducted under the guidelines of the Oregon State University Animal Care and Use Committee (project #3605) to ensure methods were in compliance with the Animal Welfare Act and United States Government Principles for the Utilization and Care of Vertebrate Animals Used in Testing, Research, and Training policies. Cranes were captured under CDFW permit SC-803070-02 and U.S. Geological Survey federal banding permit MB#21142.

We mapped each roost site, categorized the habitat as either wetland or flooded cropland, noted whether the site was used for waterfowl hunting, calculated the density of hunting blinds, and estimated the size (ha) of each using ArcGIS version 9.2 (ESRI, Redlands, California). Many of the individual sites were directly adjacent to each other (separated by dikes or secondary roads) and individual cranes tended to shift their choices for roosting among adjacent sites. We mapped adjoining sites of the same type (i.e., agriculture or wetland) as 1 site, rather than each field or wetland separately. Sites either >200 m apart, separated by paved roads or rivers, or adjacent to roosts of different habitat types were mapped separately. We calculated the mean ± SE size for wetland and agricultural roosts sites and complexes of associated roost sites, and compared the means using a Student's *t*-test.

We conducted biweekly counts of cranes using the 3 major night roost complexes in our study area (Staten Island [including the adjacent Brack and Canal Ranch Tracts], Cosumnes River Preserve, and Stone Lakes NWR) between 5 October 2007 and 27 February 2008 to document seasonal abundance of cranes and compare abundance with roost site size (ha) and type (wetland versus agricultural). We conducted each count over a period of 2 or 3 days, but all sites within each roost complex were counted on the same night. We conducted surveys by stationing observers with

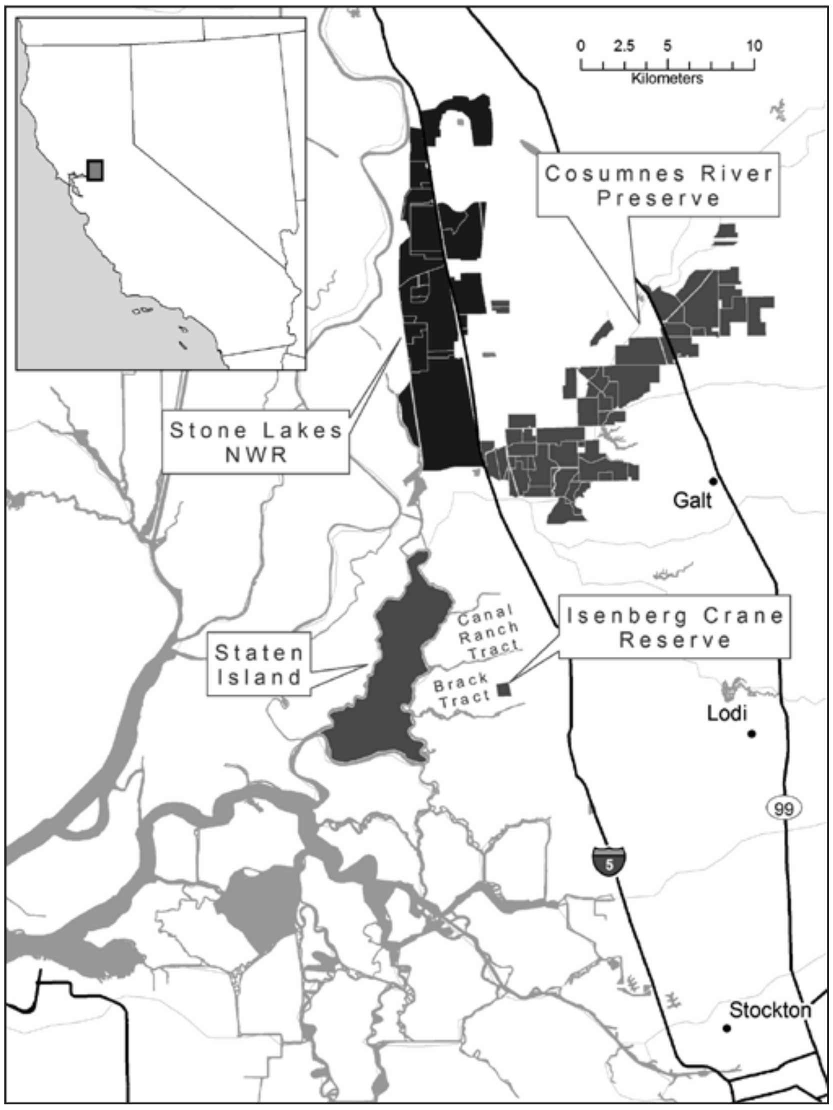

Figure 1. Map of the Sacramento-San Joaquin Delta study area where characteristics of sandhill crane (*Grus canadensis*) winter night roosts were studied, 2007-2009.

binoculars at key locations around a roost complex to count all cranes as they flew into a roost site at sunset or during early morning before they left their roost. We used roost counts at our major roost sites to relate roost size with peak roost site counts in 2007-08. We used linear regression to test the hypothesis that size of the roost site or complex was an important determinant of crane population size at a roost site or complex. Count data were not normally distributed, so we used a square-root transformation to normalize the data. We combined our roost counts and roost site areas for each of 4 habitat complexes (Cosumnes Preserve, Staten-Brack-Canal Ranch, and Stone Lakes NWR) and used peak counts at roost complexes for each roost complex size, which changed over time. We used a Student's *t*-test to compare crane densities between the 2 roost site categories (wetland versus flooded cropland).

We used observations of cranes at night roost sites to characterize water depths chosen by cranes. Roosts were visited during early morning periods, before all cranes had departed the roost. Because roosting cranes are not all independent (e.g., family groups and flocks roost together) our unit of analysis was subgroups or individual cranes of the same subspecies within a flock roosting at the same depth. For example, within a cluster of cranes, a group of cranes of the same subspecies standing together at the same depth were measured as 1 sample, while other groups or individuals standing at different depth were measured as a separate sample, which included several or single individuals. Water depth measurements were estimated visually as the proportion of a crane's tarsometatarsus that was submerged. Values were recorded to the nearest 10% increment. We converted the percentage value to water depth by multiplying each by the average tarsometatarsus length for each subspecies (from Johnson and Stewart 1973) adjusting values by 1.5 or 2 cm to account for height of the foot for lessers and greaters, respectively. We hypothesized that flooded croplands would support higher densities of cranes as field topography is relatively level compared with wetlands, so a larger percentage of the area would provide optimal depths for roosting. We used a Student's *t*-test to compare roost water depths between the subspecies and between the 2 roost site types (wetland habitat versus cropland). All means are reported ± SE.

We qualitatively assessed the impact of waterfowl hunting disturbance on roost site use by cranes by observing crane behavior at roosts before, during, and after the waterfowl hunting season relative to the density of hunter blinds and frequency at which hunting occurred at each roost site. Waterfowl hunting occurred on portions of all roost complexes that we surveyed, including the Cougar Wetlands Unit of the Cosumnes Preserve, the wetlands of the Sun River Unit of Stone Lakes NWR, and most of the flooded sites at Staten Island. Hunting at the Cougar Wetlands was administered by the Bureau of Land Management (BLM), that permitted all-day hunting from 6 permanent blinds, every Saturday during waterfowl season at a comparably high density (4 ha/blind). Hunting on the Sun River Unit roost site was administered by the U.S. Fish and Wildlife Service (USFWS) on a reservation system for 7 permanent blinds at a density of 5 ha of water area per blind. Hunting was allowed from a half hour before sunrise until noon on Wednesdays and Saturdays during the season (early October - late January). At Staten Island, the hunt program was

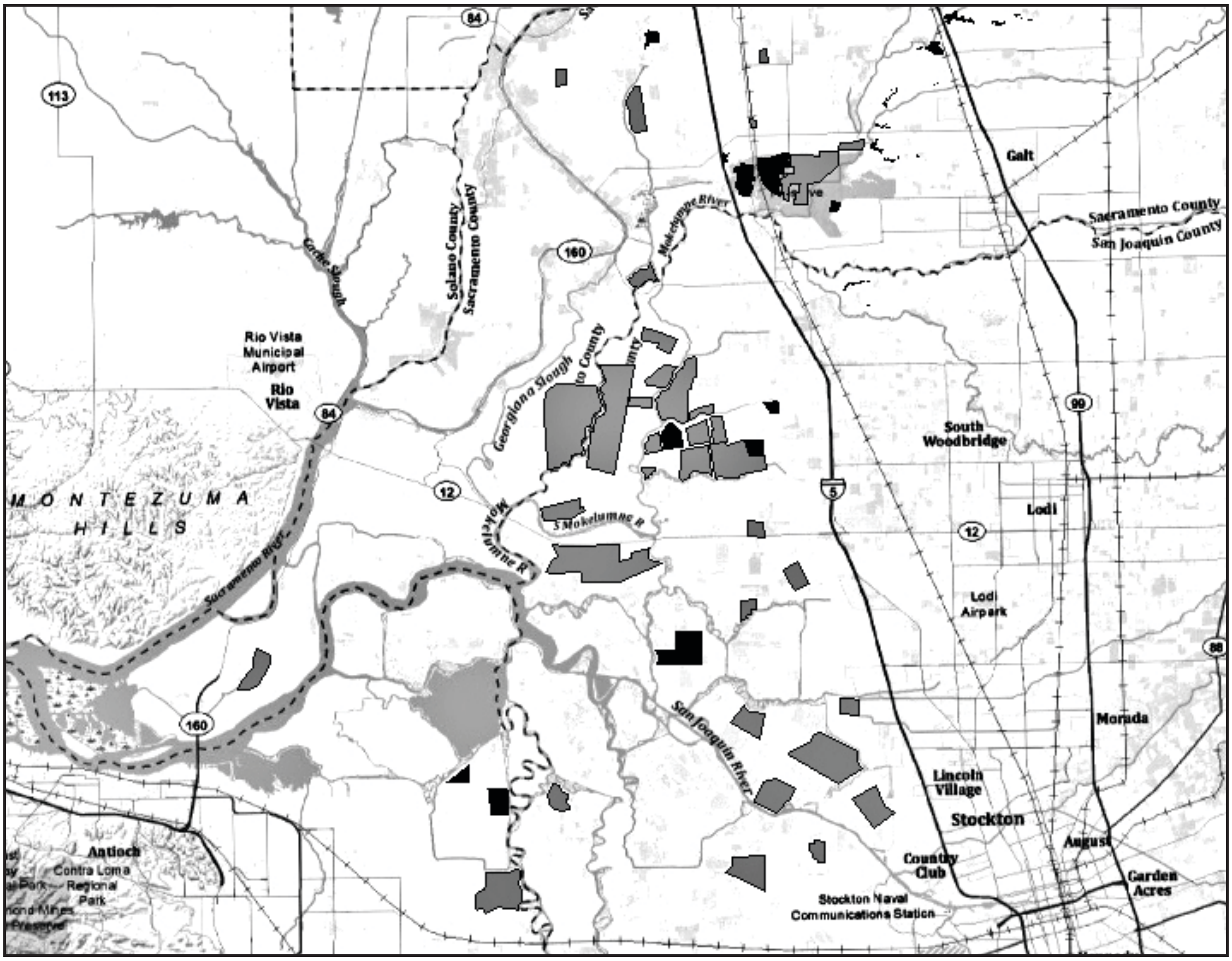

Figure 2. Location of winter night roost sites used by sandhill cranes (*Grus canadensis*) in the Sacramento-San Joaquin Delta, 2007-08 and 2008-09 (Black = wetland roosts; Dark Grey = flooded cropland roosts).

administered by the property manager. Hunting was limited to 12 permanent blinds placed at low density (63 ha/blind). Waterfowl hunting was allowed from a half hour before sunrise until 10 AM on Wednesdays, Saturdays, and Sundays.

RESULTS

We mapped 69 sites used as night roosts in the Delta (Fig. 2): 35 sites in flooded croplands and 34 sites in seasonal wetlands. Most wetland roosts were managed as seasonal or semipermanent wetlands and typically flooded through fall and winter; fields were primarily post-harvest grain fields (e.g., rice, corn, or wheat) flooded after harvest through winter. Timing and duration of flooded fields varied considerably, primarily to meet the objectives of farmers, with the exception of fields on the conservation areas which were generally flooded most of the fall and winter period specifically to provide for crane and waterfowl use. Managed roost sites were typically flooded through fall and winter, while other sites were temporarily available following heavy rains, or because of flooding for cropland management. Of the wetland roost sites, approximately 90% were constructed wetlands. Roost sizes ranged between 27 and 2,068 ha and averaged 117 ± 20 ha (median 52 ha). Cropland roost sites were larger (191 ± 33 ha) than wetland roost sites (49 ± 10 ha; $t = 4.32$; $P < 0.0001$).

We collected data on peak roost site population size for 19 roosts within our 5 main roost complexes. Larger roost sites supported larger peak numbers of cranes ($R^2 = 0.54$; $t = 3.09$, $P < 0.1$). Similarly, larger roost complexes supported larger peak numbers of cranes

($R^2 = 0.58$; $t = 4.56$, $P < 0.01$). For all sites, the mean density was 1.4 ± 0.26 cranes/ha and the slope of the relationship between density and roost site size was zero ($R^2 = 0.01$; $P > 0.05$), indicating that crane density did not change with roost size. The mean density of cranes using cropland roost sites (1.9 ± 0.31 cranes/ha) was higher than for wetland roost sites (1.0 ± 0.22) ($t = 2.55$; $P < 0.05$).

We estimated water depth on 94 individual or groups of cranes ($n = 46$ lessers and 48 greaters) at 19 different roosts on 16 different days between 1 February 2008 and 20 November 2008. Mean roost water depth was similar between agricultural and wetland roost sites ($P > 0.60$) and mean roost depth used was similar between greaters (10.3 ± 0.6 cm) and lessers (10.6 ± 0.6 cm; $t = 0.33$, $P = 0.75$).

The impact of hunting intensity varied by roost complex. We never observed cranes roosting at the Cougar Wetlands Unit, which had a high density of hunting blinds and was hunted all day, every Saturday during waterfowl season. Cranes used the Sun River Unit for roosting in early October during 2007 and 2008, before waterfowl season opened; however, they left the site after opening day both years, and were only infrequently found roosting there following the initial hunting disturbance, each hunting season. In 2008, before the hunting season started, we recorded a peak of 286 cranes roosting in the Sun River Unit, while no cranes roosted there the night of opening day of hunting, and we only found cranes roosting there twice (totaling 31 and 38 cranes) out of 9 subsequent bi-weekly counts (7 during hunting season). Also, one of our radio-tagged greaters was roosting there from its arrival in the region on 5 October, through the night before the opening of waterfowl hunting on 18 October. Following the opening day hunt, it moved with other cranes at the site to the Cosumnes River Preserve. Cranes continued to use hunted roost sites throughout the waterfowl season at Staten Island. The number of cranes roosting on Staten Island actually increased (by 36%), immediately after opening day of waterfowl season, suggesting that Staten Island recruited birds that were displaced from other hunted roost sites in the area.

DISCUSSION

The typical roost site in our study was a large expanse of open, shallow water that was mostly isolated from disturbance. A North Dakota study identified large expanses of shallow water not close to shore as the most important roost site characteristics (Soine 1982), while studies along the Platte River in Nebraska determined that areas of wider river channels received higher crane use (Krapu et al. 1984; Norling et al. 1992; Folk and Tacha 1990; Parrish et al. 2001; Davis 2001, 2003). Along the Platte River, roost sites disturbed by nearby roads or bridges supported lower densities of roosting cranes (Krapu et al. 1984, Parrish et al. 2001). Also, an Indiana study reported that the nearer a roost was to another roost, the more likely that it would be used (Lovvorn and Kirkpatrick 1981).

A high percentage (48%) of the roost sites that we documented were flooded croplands, a habitat type that has rarely been reported in other winter studies. Cropland roost sites were mentioned as being used during migration in Indiana (Lovvorn and Kirkpatrick 1981). Other studies reported cranes roosting on managed and natural wetlands in Indiana, North Dakota, Colorado, Nebraska, Alaska, Georgia, and California (Lovvorn and Kirkpatrick 1981, Soine 1982, Kauffeld 1982, Iverson et al. 1987, Bennett and Bennett 1989, Pogson and Lindstedt 1991), flooded playas and shallow lakes in Texas and North Dakota (Lewis 1976, Carlisle and Tacha 1983, Iverson et. al 1985), and shallow riverine sites along the Platte River in Nebraska (Krapu et al. 1984, Norling et al. 1992, Folk and Tacha 1990, Parrish et al. 2001, Davis 2001, 2003). In California, a previous study in the Delta also documented cranes using flooded fields for roosting (Ivey and Herziger 2003), but a study in the early 1980s did not document such use in the Delta (Pogson and Lindstedt 1991). Flooding of grain fields as a general practice has increased in northern California over the past 2 decades (Fleskes et al. 2005), primarily for agricultural purposes, but also to provide waterfowl hunting opportunities and in specific cases on our study area in an effort to provide roost sites for cranes. Our results suggest that sandhill cranes will readily adapt to using flooded agricultural fields as roost sites and that flooding cropland is one option for creating sandhill crane roosts.

The mean density of cranes roosting in flooded croplands was higher than in wetlands. We believe this was because flooded croplands tend to provide more area of ideal roost water depths due to their flat topography, and also because they were usually adjacent to unflooded grain field foraging sites. However, wetland roost sites likely provide additional values beyond just water depth to cranes, such as providing alternate foods like macroinvertebrates. A Nebraska study reported that cranes preferred wetlands during the day (Iverson et al. 1987), and a previous study in the Delta also documented preference for wetlands (Ivey and Herziger 2003). During our study the majority of cranes roosted at cropland sites because, on average, roosts in agricultural fields were larger than wetland roosts and crane density was highest in agricultural roosts.

We found positive relationships between roost site size and crane abundance at a roost at both the individual roost site and roost complex scales. An Indiana study (Lovvorn and Kirkpatrick 1981) found that roost sites were more likely to be used if they were near other roost sites, but no other study has examined the relationship between roost size and either peak count or crane density. In landscapes managed for wintering and staging cranes, it is important to understand how much roost water should be available, as there is a trade-off between increasing the size of a roost site versus maximizing suitable foraging habitat. Areas inundated to provide roost habitat are not generally good foraging habitat for cranes. Roost size only explained about half the variation in our data; other likely factors influencing bird use of roosts include food availability in the foraging landscape around roost complexes, migration timing, disturbance (e.g., hunting), and changing conditions at other roost sites (e.g., dewatering, disturbance increase). These additional factors could be explored in greater depth if a more complete understanding of crane roosts is desired.

The water depths used by cranes at each roost in our study was similar to what cranes have used in other regions that are thought to provide high quality habitat. Cranes in our study used depths ranging from 3 to 21 cm, with a mode of 7 cm. Similarly, along the Platte River in Nebraska, cranes were reported to prefer depths of 1–13 cm for roosting, with the highest proportions of depths used being between 1 and 7 cm (Norling et al. 1992), and ≤ 21 cm by Folk and Tacha (1990). Other studies in Nebraska, Indiana, and Oregon have reported that cranes roosted in water less than 20 cm deep (Frith 1976, Lovvorn and Kirkpatrick 1981, Latka and Yahnke 1986, Littlefield 1986, Armbruster and Farmer 1992, Norling et al. 1992). In 1 exception to this pattern, a study along the North Platte River in Nebraska documented 14% of the cranes using depths from 21 to 35.6 cm (Folk and Tacha 1990).

Although our data are qualitative, when cranes have a choice, it appears they prefer to avoid sites used for waterfowl hunting as night roosts. Some temporarily used roost sites were only used before or after waterfowl season. Our results are similar to findings in Indiana (Lovvorn and Kirkpatrick 1981), while a study in Saskatchewan documented that cranes would not tolerate repeated hunting disturbance at roosts (Stephen 1967). Even with very limited waterfowl hunting at the Sun River Unit, cranes immediately left the site for a few weeks and were only found roosting there on 2 of 7 surveys later during the waterfowl season. Cranes in Michigan and Wisconsin also abandoned roosts on or immediately after the opening day of waterfowl hunting season (Walkinshaw and Hoffman 1974, Bennett 1978). Most hunted sites in the Delta are hunted all day, usually 3 days a week (Wednesday, Saturday, and Sunday), which limits opportunities for cranes to roost or loaf during the day at these sites. Based on our observations of the hunting program at Staten Island, cranes seem particularly sensitive to hunting disturbance in the late afternoon when they are flying to roost sites and also during mid-day when they often use roost sites for loafing.

Staten Island was an exception to the general rule that cranes avoided hunted sites as roosts. This is likely in part because most of the permitted hunters were only able to hunt on Sundays, resulting in low hunting frequency. Similar to other hunted roost sites, cranes are flushed from Staten Island roosts when shooting begins, but because hunting is only allowed until 10:00 AM, cranes have a chance to return to the sites undisturbed to loaf in late mornings (they usually return about 11:00 AM) and to roost in the evenings. Cranes at Staten Island may also tolerate the hunting disturbance better, because of lower hunter density and larger roost sites. The pattern of increased roosting numbers at Staten Island following opening day was also noted in a previous study (Ivey and Herziger 2003).

MANAGEMENT IMPLICATIONS

To plan for crane roost sites for a given population objective for cranes, we suggest (based on the mean density of 1.4 ± 0.26 cranes/ha that we observed) using a ratio of 1.5 cranes/ha (~60 cranes/100 acre) as a minimum roost site area goal. Considerations for design and management of wetlands and flooded cropland roosts include providing large roost site complexes (100-1000 ha, depending on the number of cranes to support) because larger sites likely give cranes more security from predators. Individual sites within a managed roost complex should be >5 ha, of mostly level topography, and dominated by shallow water (5-10 cm depths). The depth of water used by cranes may be a reasonable indicator of roost site availability. We suggest that if cranes are commonly seen roosting where water depths are greater than 20 cm, it is an indication that ideal roost sites are limited. Seasonal wetlands will provide more values to cranes than flooded croplands, but flooded croplands may be a better option for building crane habitat into a working agricultural farm. Flooding of croplands to provide temporary roost sites might also be of value to expand crane roosting habitat options in other crane wintering or staging regions.

Disturbance caused by waterfowl hunting appears to limit crane use of roost sites; thus, we suggest these 2 uses should not be considered readily compatible. However, if the management objective of an area includes waterfowl hunting, then the Staten Island program of very low hunter densities and limited, early morning hunting, can serve as a model for a crane-compatible waterfowl hunt program.

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