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WINTER DISTRIBUTION OF SANDHILL CRANES FROM UPPER MICHIGAN AND ADJACENT ONTARIO—A THIRTY-YEAR PERSPECTIVE

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Abstract: The relationship between areas used for breeding and wintering by the expanding Eastern Population of greater sandhill cranes (*Grus canadensis tabida*) has been little studied. During 1985-1988, 32/33 (97%) of sandhill cranes VHF-radiotagged on Seney National Wildlife Refuge (NWR) in the Upper Peninsula of Michigan were subsequently located on wintering areas in wet prairies, muck farms, and improved pastures in Florida and southern Georgia. Four additional radiotagged cranes from other areas of Upper Michigan and 7 from the North Channel of Lake Huron, Ontario, were also located in similar areas and habitats. Winter area was not dependent on summer location, but there was a tendency for cranes from the eastern portion of Seney NWR to winter near Blue Cypress Lake in south-central Florida. With few exceptions, individual cranes remained on their respective primary winter areas through January until late February when spring migration began. Fidelity to wintering areas from year to year was 85%. Winter distribution of cranes from Upper Michigan and adjacent Ontario was similar to the widespread but clumped distribution exhibited by the entire Great Lakes population. Comparable recent data (2010-2018) from other studies demonstrated expansion of winter distribution of Upper Michigan and Ontario cranes along the migration route from Indiana to Florida, similar to the Eastern Population of greater sandhill cranes in general. More limited wetland habitat north of Florida often resulted in larger flocks dependent on roost sites on public land rather than the more dispersed distribution in the historical winter areas in Florida. Although the Eastern Population of sandhill cranes has increased from 30,000 to possibly 90,000 or more individuals during the past 30 years, little recent research on wintering has occurred, especially within the changing landscape of Florida. Further documentation of crane numbers, areas used, and current roosting and feeding habitat is needed.

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Key words: *Grus canadensis tabida*, Eastern Population, Florida, North Channel of Lake Huron, Ontario, sandhill crane, Seney National Wildlife Refuge, Upper Michigan, winter distribution.

Habitat loss and indiscriminate shooting by humans nearly extirpated the Eastern Population of greater sandhill cranes (*Grus canadensis tabida*) by the early 1900s (Walkinshaw 1949). A few hundred individuals survived in remnant breeding areas in Upper and Lower Michigan and in Wisconsin. Descendants of most of these birds migrated to a stopover site in northwestern Indiana at Jasper-Pulaski Fish and Wildlife Area (FWA), a managed wetland within the watershed of the formerly extensive (>200,000-ha) Grand Kankakee Marsh, which had been completely drained for agricultural development by the early 1900s. From this site, migration continued on a direct route to wintering areas in southern Georgia and peninsular Florida (Williams and Phillips 1972, Melvin 1977, Nesbitt and Williams 1979, Toepfer and Crete 1979, Walkinshaw 1982, McMillen et al. 1991).

The population began a slow recovery and then significantly increased in the 1970s, when it surpassed 10,000 birds. In the 1980s, major wintering areas of the Eastern Population of greater sandhill cranes were limited to southern Georgia and peninsular Florida (Walkinshaw 1949, 1982; McMillen 1988; Urbanek et al. 1988) with only much smaller numbers of scattered birds wintering farther north (Dewhurst and Zwank 1986). Since then the winter distribution has greatly expanded to include large numbers of cranes in Indiana, Kentucky, Tennessee, Alabama, and Louisiana (Aborn 2010; King et al. 2010; Urbanek et al. 2014; Fronczak et al. 2017; W. Gates, U.S. Fish and Wildlife Service, unpublished data). By 1990, the population had reached just over 30,000 (Urbanek 1991). Later estimates, although subject to additional error due to logistics of counting as the distribution expanded in time and space, were >90,000 cranes by 2016 (Dubovsky 2017).

Beginning in 1984 and with additional studies continuing through 1993, the former Ohio Cooperative Fish and Wildlife Research Unit began a sandhill crane research program to evaluate the Upper Peninsula of Michigan as a possible reintroduction site for endangered whooping cranes (*Grus americana*). This paper includes results from that program on winter distribution encompassed in 2 unpublished reports of sandhill cranes banded on

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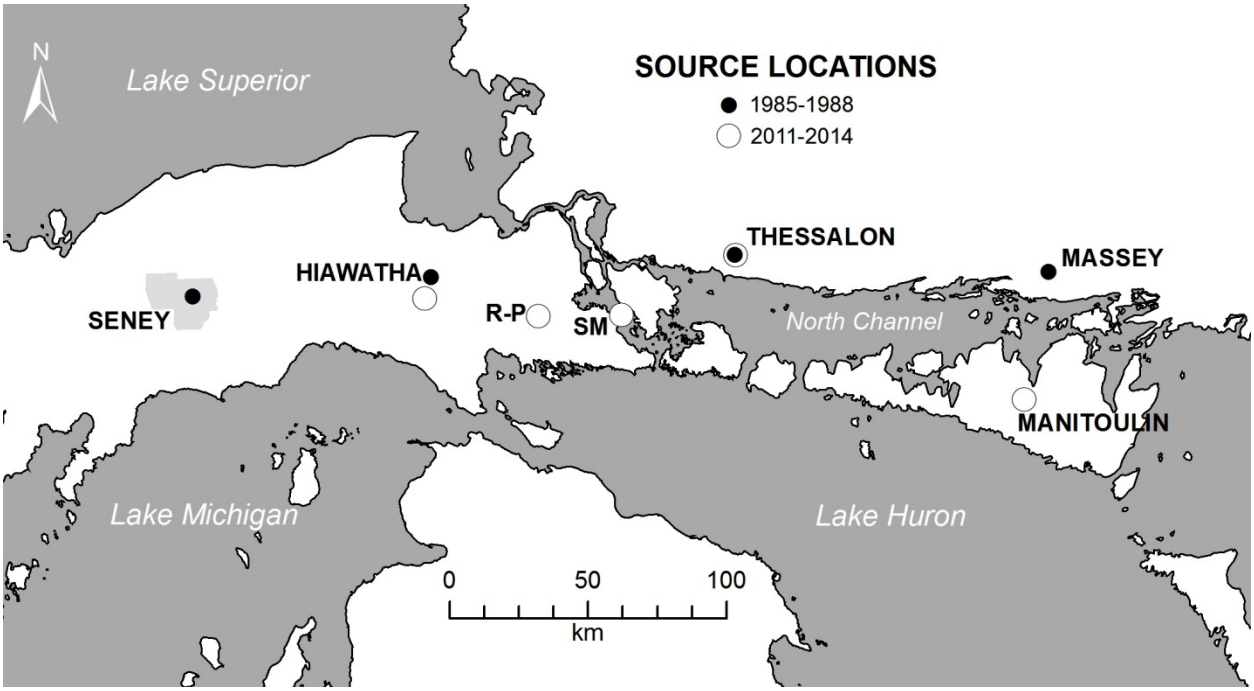

Figure 1. Summer areas of sandhill cranes in Upper Michigan and along the North Channel of Lake Huron, Ontario, for study of winter distribution. Summer locations 2011-2014 data are from Fronczak et al. (2017). Seney = Seney National Wildlife Refuge, Hiawatha = Hiawatha National Forest (East Unit), R-P = Rudyard-Pickford, SM = St. Marys River north of Raber, Thessalon = Thessalon-Iron Bridge, Manitoulin = Manitoulin Island.

Seney National Wildlife Refuge (NWR) in Upper Michigan (Urbanek et al. 1988) and along the north shore of the North Channel of Lake Huron, Ontario (Urbanek 1988). Those data from 1985-1988 are compared with available information on the recent (2010-2018) winter distribution of remotely tracked sandhill cranes from the same northern geographical areas (see Methods).

STUDY AREAS

The primary source of cranes studied was the 38,631-ha Seney NWR in Schoolcraft County in the east-central Upper Peninsula of Michigan (46°15′N, 86°04′W; Fig. 1). Palustrine habitats without tree canopies comprised most of the area used by cranes and consisted of 3 general habitat types: cattail (*Typha latifolia*) marsh, sedge (*Carex* spp.) marsh, and *Sphagnum* moss-leatherleaf (*Chamaedaphne calyculata*) bog or fen. Successional stages, especially of sedge marsh, contained few or no shrubs to extensive stands of willows (*Salix* spp.). Areas with greatest numbers of cranes were usually associated with large managed impoundments (Urbanek and Bookhout 1992*a*). Some cranes monitored during the study were banded 75 km east of Seney NWR on the East Unit of the Hiawatha National Forest (NF; 46°18′N, 84°56′W). Wetlands in that area were mainly bogs dominated by *Sphagnum* and leatherleaf (Taylor 1976).

The Ontario study area extended from Thessalon to Iron Bridge along the north shore of the North Channel of Lake Huron in addition to an eastern site near Massey (Fig. 1). These primarily agricultural areas produced barley, oats, and hay; cattle production and dairy farming were common. In addition to marshes in the Dayton-Eley Swamp, the area contained many small lakes with marshy or boggy edges and wetlands created by extensive beaver (*Castor canadensis*) activity. Like the Upper Peninsula of Michigan, leatherleaf, *Sphagnum*, sedges, and cattail were common wetland species. Comparative data for cranes from these areas during the 2010s were obtained from studies of cranes radiotagged on Manitoulin Island (Hanna 2017), which forms the southern border of the North Channel (Fig. 1), and cranes radiotagged on migration and winter areas (Fronczak 2014) and that later were found to summer in Upper Michigan or Ontario.

METHODS AND MATERIALS

1984-1988

During the period 1984-1987, I uniquely marked 214 sandhill cranes on Seney NWR with colored plastic leg bands; solar/Ni-Cad-powered VHF radiotransmitters (164-165 MHz; Telemetry Systems, Inc., Mequon, WI, USA) were attached to leg bands on 33 of these birds. Only 1 member of a pair or family group (usually the adult male) was radiotagged. An additional 12 cranes, including 5 that were radiotagged, were captured by staff

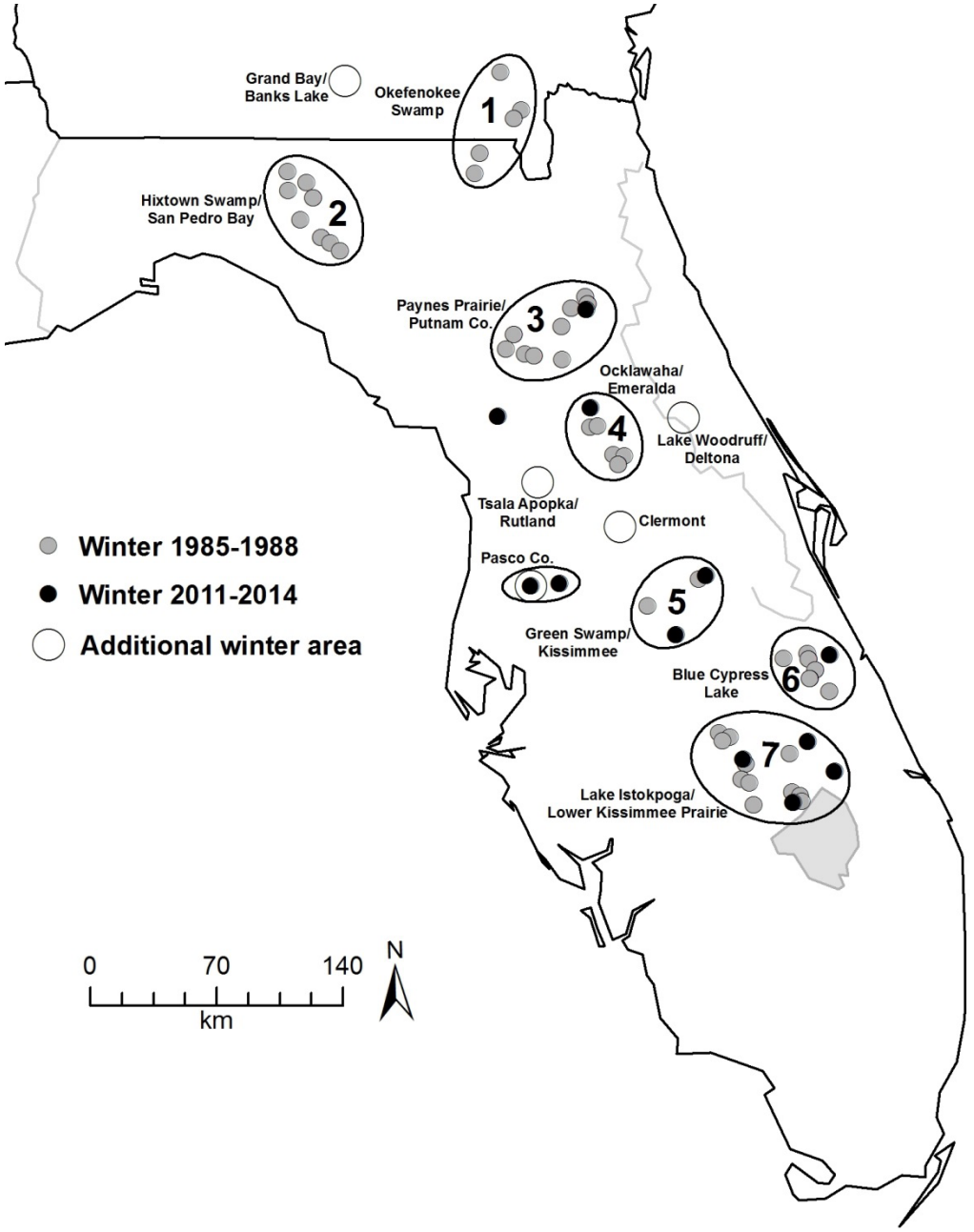

Figure 2. Locations of wintering greater sandhill cranes from the Upper Peninsula of Michigan and along the North Channel of Lake Huron, Ontario. All cranes tracked in 1985-1988 wintered only in southern Georgia and peninsular Florida and within the numbered regions indicated by ellipses (see Table 1). Cranes in 2011-2014 (data from Fronczak et al. 2017) wintered at widespread additional locations (Fig. 3). Open circles = other major wintering areas (>500 birds) of the Eastern Population.

of the Hiawatha NF in 1986-1987. In 1987 I captured and color-marked 26 cranes in the Ontario study area and equipped 8 of the adult males with radiotransmitters (6 solar/Ni-Cad as above and 2 powered by lithium batteries [Telonics, Inc., Mesa, AZ, USA]). Captures were mainly by rocket-netting (Urbanek et al. 1991) in late summer.

I conducted aerial searches during the winters of 1985-86, 1986-87, and 1987-88 for cranes radiotagged on Seney NWR. During the latter 2 winters, I also searched for 3 and 5 extant cranes, respectively, originating from the East Unit of the Hiawatha NF and in winter 1987-88 for the 8 cranes radiotagged in Ontario. Aerial searches occurred in areas of known winter concentrations identified by S. Nesbitt, Florida Fish and Wildlife Conservation Commission (formerly Florida Game and Fresh Water Fish Commission). Searches were from Cessna 172 or similar aircraft with a Telonics scanner/receiver (Model TS-l/TR-2) and 2 strut-mounted directional H-antennae. One antenna was vertically oriented, outward-facing, and aimed 10° below the horizontal axis of the plane; the antenna on the other strut was forward-facing, horizontally oriented and aimed 22° below the horizontal axis. Search altitude was usually 610-760 m above sea level, and speed was approximately 160-176 km/hour.

Approximately 23.1 hours were flown on 8 days between 16 December 1985 and 10 March 1986. Efforts were concentrated in north-central Florida and around Blue Cypress Lake (Fig. 2). Except for the latter area, others areas south of Orlando, as well as the Okefenokee and Hixtown Swamp/San Pedro Bay areas in the north, were not extensively searched. During 1987 a more intensive air search was conducted; 11 flight-days totaling 51.7 hours were made between 7 and 29 January. A January time frame ensured that birds were on their primary wintering areas (PWA) and not migrating; all major areas were thoroughly covered. For 93% of the observations, the exact location of each bird was determined by establishing visual contact. During 1988 all known major winter areas were searched on 3 flight-days totaling 16.4 hours between 13 and 22 January. Four flights totaling 10.5 hours were also made from 29 January to 21 February specifically to find missing birds. I also recorded observations of radiotagged and other color-marked birds from the ground during all 3 winters as well as on breeding areas and along the migration route. These observations provided records of functionality of radiotransmitters, especially at Jasper-Pulaski FWA, the major autumn stopover area, where cranes were concentrated in open fields and easily visually observed.

2010-2018

To represent recent winter distribution of sandhill cranes from Upper Michigan and adjacent Ontario, I used a subset of data from Fronczak et al. (2017). These data were collected during concurrent studies of foraging and staging of cranes on Manitoulin Island in Lake Huron (Hanna et al. 2014, Hanna 2017) and migration ecology of the Eastern Population of greater sandhill cranes (Fronczak 2014). Banding of cranes in those studies occurred from July 2010 to January 2012 and included 2-4 subsequent summer and 1-4 subsequent winter locations per bird. Nine of these birds were banded on breeding or staging areas on Manitoulin Island, and 7 were banded on major migration or wintering areas, including Jasper-Pulaski FWA and Hiwassee Wildlife Refuge (Fig. 3), in addition to a few other locations. Those researchers captured cranes primarily by rocket-netting and equipped them with leg band-mounted global positioning system (GPS) satellite platform transmitting terminals (PTTs) (North Star Science and Technology, Baltimore, MD, USA).

Finally, in January 2018 I sent an inquiry to governmental personnel and private individuals with knowledge of sandhill cranes to ascertain current status of wintering areas in their respective states. To avoid inclusion of migrating birds, I used these criteria to identify major wintering sites: >500 birds present for at least 18 consecutive days of which some days occurred within 10-31 January during at least 2 winters during 2016-2018. Because large winter flocks in southern Georgia and peninsular Florida were widely dispersed and have not been recently surveyed, current status in those areas was presumed to include most of the previous historical and recent wintering areas. Included in the latter category here are data from Urbanek et al. (2005, 2014).

RESULTS

As confirmed by subsequent nest surveys (Urbanek and Bookhout 1992*a*), all of the cranes radiotagged on Seney NWR were local cranes from east-central Upper Michigan. Most breeding territories were on or adjacent

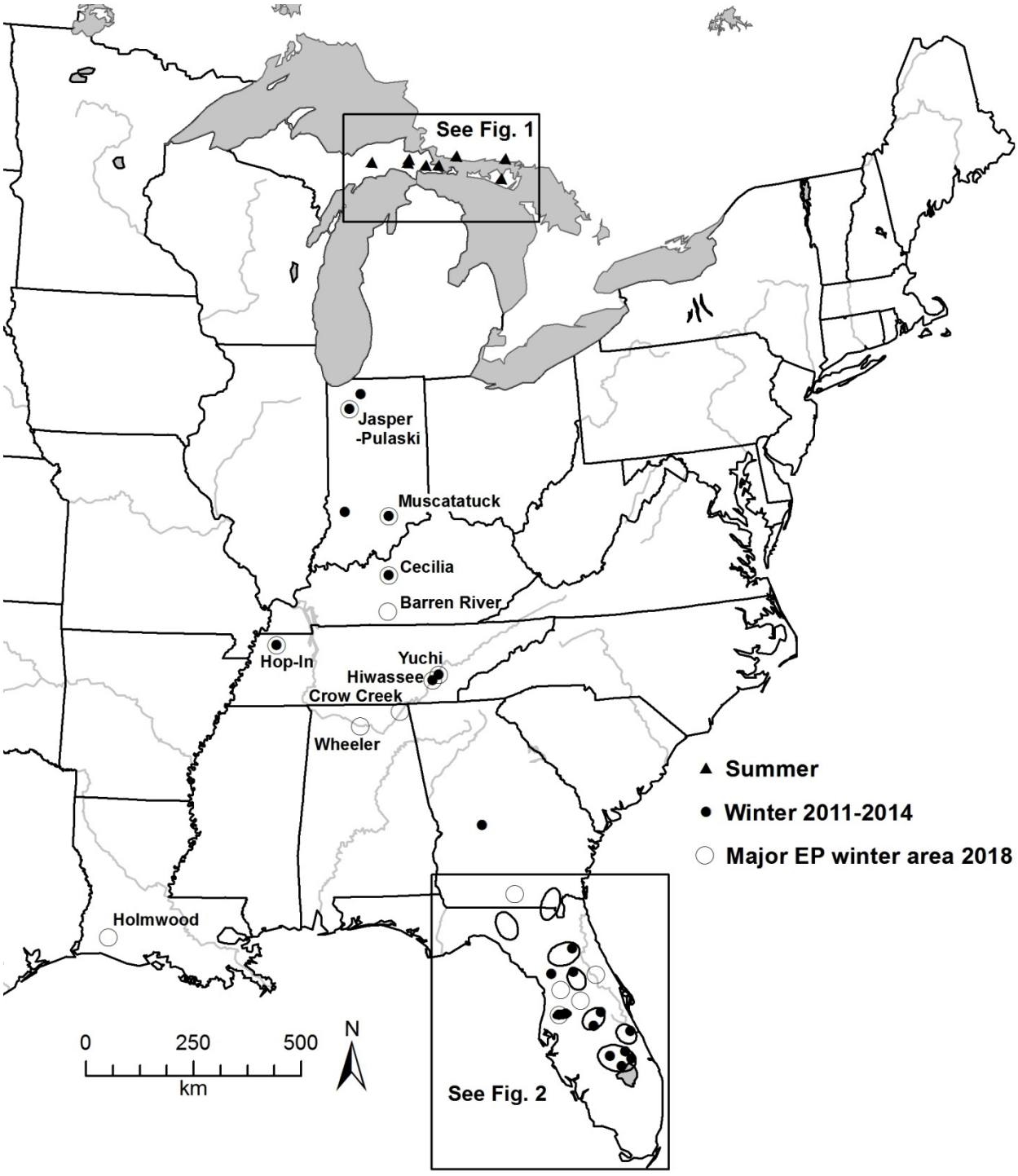

Figure 3. Winter distribution of sandhill cranes from Upper Michigan and along the North Channel of Lake Huron (detail in Fig. 1), 1985-88 and 2011-2014 (detail of southern Georgia and peninsular Florida portion in Fig. 2). Winter 2011-2014 data are from Fronczak et al. (2017). Open circles = major wintering areas (>500 birds) of the Eastern Population (EP).

to the refuge; the farthest was 55 km northeast (Fig. 4). Observations and tracking also indicated that cranes radiotagged on the Hiawatha NF and near Thessalon (Fig. 1) were local birds. The origin of the cranes captured on the staging area near Massey was not determined. All cranes tagged by Hanna et al. (2014) on

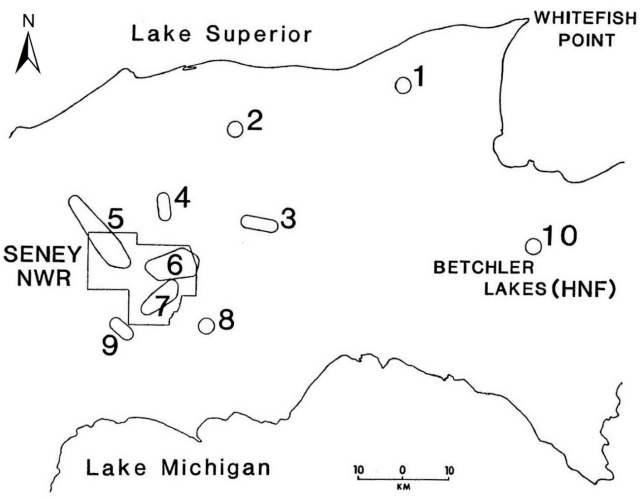

Figure 4. Upper Peninsula of Michigan breeding areas (1-9) containing territories of 35 greater sandhill cranes radiotagged on Seney National Wildlife Refuge in 1985-1987. 10 = general area of captures on Hiawatha National Forest (East Unit). Wintering areas of cranes from these numbered areas are indicated in Table 2.

Manitoulin Island returned to the same general area in subsequent years. Likewise, each of the cranes tagged by Fronczak et al. (2017) during migration or winter and that were recorded in Upper Michigan or Ontario during the following summer also returned to those same general areas in subsequent summers.

Upper Michigan Cranes 1985-1988

Distribution.—During winter 1985-86, I located 14 of 17 radiotagged cranes. During winter 1986-87, all 28 cranes radiotagged at Seney NWR and known to be alive that winter were located; 26 initially were detected from the air and 2 with nonfunctional transmitters were visually observed from the ground. During winter 1987-88, I found 27 of 31 Seney-radiotagged cranes, including all of those with functional transmitters. Four radiotagged cranes from the East Unit of the Hiawatha NF were also found in the latter winter as well as 1 in the previous winter. At the same locations I also observed more than 50 cranes that had been color-banded in Upper Michigan but were not equipped with radiotransmitters.

Cranes captured on Seney NWR wintered in 7 general areas (regions) from the Okefenokee Swamp in the north southward to Lake Okeechobee. These regions included Okefenokee and associated swamps, San Pedro Bay-Hixtown Swamp, 2 areas of concentration in north-central Florida, Blue Cypress Lake, and Lake Istokpoga-Lower Kissimmee Prairie (Table 1, Fig. 2). In addition, cranes from the Hiawatha NF were located in the Green Swamp and near the town of Kissimmee. Cranes in the 2 northern regions used wet prairies and openings in swamps as primary habitat. Cranes in north-central Florida were found in wet prairies, pastures, and on muck farms. The latter category consisted of drained wetlands of humus-rich soil and corn as the principal crop. Cranes in the 2 southernmost regions occurred primarily in improved cattle pastures and associated ponds. Radiotagged cranes wintered mainly on private lands except for cranes on Okefenokee NWR and in some other northern swamps, Ordway-Swisher Preserve (Putnam County), Mud Prairie Lake (Ocala NF), and the St. Johns Water Management District (south of Blue Cypress Lake) (Table 1).

Although cranes with summer territories on or near Seney NWR wintered at widespread locations, pairs from the eastern part of the refuge tended to winter in the improved pastures northwest of Blue Cypress Lake (Table 2). Eight of 14 radiotagged birds from the eastern part of the refuge (areas 6 and 7, Fig. 4) wintered near Blue Cypress Lake (Fig. 2) during 1986-87 and 7 of 16 wintered there in 1987-88, much higher proportions than in any other winter area.

Timing of Occurrence on Primary Wintering Areas.—The earliest date on which a crane from Seney NWR was reported on its PWA was 12 November. Another crane was still at a migratory stop, i.e., had not yet arrived on a winter area, on 19 December. Based on duration of stay at southernmost locations, all cranes were on their PWAs when they were found in January. Most cranes remained at or near the PWA until beginning spring migration. During 1986, 3 of 6 cranes checked on the north-central area of Florida had begun migration by 24 February. Initiation of spring migration by 3 radiotagged birds in that same group occurred on 27 February for 2 birds and on 28 February for the other in 1987. Some color-marked cranes from Seney NWR were observed in Florida as late as 13 March. Stopover points included the Okefenokee Swamp and Emeralda muck farms (Table 1). Paynes Prairie Preserve was used as a spring stopover site by 3 Upper Peninsula birds during 23-27 February 1987. Although several cranes wintered on adjacent ranches and wetlands, no radiotagged birds wintered on the preserve property in any of the 3 winters.

Table 1. Locations of greater sandhill cranes radiotagged in Upper Michigan, winters 1985-86 to 1987-88, and along the North Channel of Lake Huron, Ontario, winter 1987-88. Counties are in Florida unless indicated otherwise. Sites are plotted on Figs. 2 and 3. Regions refer to numbered ellipses in Fig. 2.

Region	Location	County	Crane ID (winter[a])
1	Okefenokee Swamp (Ga.), Pinhook Swamp and Impassable Bay	Charlton and Ware (Ga.), Baker and Columbia (Fla.)	583 (86, 87, 88) 656 (88) 138 (87,88) 599 (87, 88)
2	Hixtown Swamp, San Pedro Bay, Old Grassy Lake	Madison, Taylor, Lafayette	5.041[b] (88) 101(87, 88) 964 (88) 682 (87) 997 (87) 786 (86,87,88) 157 (88)
3	Orange Grove Lake Prairie, Ashley Prairie, Ordway-Swisher Preserve, Levys and Fowlers Prairies, Paynes Prairie, Tuscawilla Lake, private ranches and farms near Florahome, Wacahoota, Evinston, and Citra	Putnam, Alachua, Marion	219 (88) 300 (87, 88) 422 (86,87) 024 (86)[c] 262 (86,87,88) 062 (86,87,88) 071 (86,87,88) 656 (86,87)
4	Private farms near Ocklawaha and Emeralda, Mud Prairie Lake, Emeralda Marsh, Lake Yale Marsh	Marion, Lake	682 (88) 481 (86) 300 (86) 138 (88) 5.020[b] (88) 257[b] (88) 633[b] (88)
5	Private farm near Kissimmee, Green Swamp	Osceola, Polk	240 (88) 043 (87,88)
6	Private ranches near Blue Cypress Lake, St. Johns Marsh	Osceola, Brevard, Indian River	342 (86, 87, 88) 178 (87,88) 320 (86, 87, 88) 457 (86, 87, 88) 980 (87, 88) 119 (87) 383 (87, 88) 536 (87, 88) 162 (87, 88) 5.059[b] (88)
7	Lake Istokpoga, private ranches on lower Kissimmee Prairie, Avon Park Bombing Range, Buck Island, Buckhead Ridge	Highlands, Okeechobee, Glades	204 (87, 88) 440 (88) 356 (88) 518 (87) 024 (87) 641 (87, 88) 840 (87, 88) 356 (88) 518 (87) 024 (87) 722 (87, 88) 119 (88) 481B[b] (88) 611[b] (88)

[a] In this table 86, 87, and 88 = winters 1985-86, 1986-87, and 1987-88, respectively.

[b] Radiotagged Ontario crane. Others are from Upper Michigan.

[c] Migrating; final wintering area unconfirmed.

Table 2. The relationship between the winter and breeding season distributions of 35 greater sandhill cranes from the Upper Peninsula of Michigan, 1985-1988. Each entry represents the number of radiotagged cranes common to both areas. For each bird that wintered in 2 areas in different winters, a value of 0.5 was assigned under each of the appropriate winter areas. Refer to Fig. 4 for location of the Upper Peninsula areas and to Fig. 2 for location of winter areas.

Upper Michigan area[a]	No. cranes	Winter area					
		Okefenokee	San Pedro Bay	North-central[b]	Blue Cypress	Istokpoga-Lower Kissimmee Prairie	Green Swamp
1	1		1				
2	1					1	
3	2			1		1	
4	3	0.5		2.5			
5	5	2		1		2	
6[c]	9		3	1	4	1	
7[c]	7		1		3.5	2.5	
8	1			1			
9	2			1	1		
10	4		1			1	2

[a] Refer to Fig. 4.
[b] Includes regions 3 (Paynes Prairie/Putnam Co.) and 4 (Ocklawaha/Emeralda) in Fig. 2 and Table 1.
[c] Eastern portion of Seney National Wildlife Refuge (see Fig. 4).

Winter Site Fidelity.—During winter 1985-86, 14 of 17 cranes radiotagged at Seney NWR were found in Florida or southern Georgia. Of the 3 cranes not found that winter, 1 later died during September 1986 and the other 2 (nos. 101 and 997) were located in 1987 in San Pedro Bay in Taylor and Madison Counties, Florida. These counties had not been searched during the previous winter. Another radiotagged crane (no. 024) was located only once in the winter 1985-86 survey at a stopover site late in migration. Of the 13 remaining cranes located, 11 (85%) were found in the same general locations during winter 1986-87 as 1985-86 (Table 2). The PWAs of 25 radiotagged cranes were confirmed during both winters 1986-87 and 1987-88. Of those cranes, 21 (84%) used the same PWA during both winters. Changes in PWA from year to year appeared related to losses of mates for 1 female and to water-level changes, housing development, and wintering at previous years' stopover sites for males (Table 3).

Social Aspects.—Nineteen (50%) of the 38 radiotagged cranes were known to have had color-banded mates. Nine of the 19 were observed from the ground on PWAs during February 1987, and all 9 (100%) were with their banded mates. Four of the 19 were observed again in February 1988, and all were also with their banded mates. Subadult cranes showed fidelity to sites where they had previously wintered as juveniles with their parents (Table 4). Juveniles had been color-banded only and could not be radiotracked.

Table 3. Summary of changes in primary winter regions by cranes radiotagged on Seney National Wildlife Refuge, Michigan, 1985-1988. Other cranes in Table 1 did not change winter regions.

Crane ID	Sex	Distance between sites (km)	Contributing factor
1985-86 to 1986-87			
682	F	216	Former mate died, wintered with new mate
300	M	88	Wintered at stopover of previous year
1986-87 to 1987-88			
682	M	192	New mate missing, returned to wintering area of former mate
119	M	60	Water level changes
262	M	28	Housing development, water level changes
656	M	135	Wintered at stopover of previous year, water level changes

Ontario Cranes 1987-1988

During the winter following banding in summer 1987, I found 7 of the 8 cranes radiotagged in Ontario on 6 Florida sites ranging from Hixtown Swamp in the north to Glades County, 470 km to the south (Fig. 2, Table 1). The winter distribution of cranes from the Ontario breeding areas was within the same widespread but clumped distribution noted for birds from the Upper Peninsula of Michigan. During the following spring migration, I twice observed in Wisconsin the only radiotagged Ontario crane not found in Florida and confirmed that the transmitter was nonfunctional. Failure to find the winter area of this bird was therefore probably not due to occurrence of the bird outside the typical wintering distribution. Ontario birds wintered with other Great Lakes cranes in freshwater marshes, wet prairies, and muck farms and on cattle ranches.

Upper Michigan and Ontario Cranes 2011-2014

Data from Fronczak et al. (2017) included 16 cranes from 5 different summer areas in Upper Michigan and Ontario. These areas consisted of the East Unit of the Hiawatha NF near Trout Lake (2), Rudyard-Pickford (2), north of Raber on the Michigan side of the St. Marys River (separating U.S. and Canada, 1), Manitoulin Island (9), and Thessalon (2) (Fig. 1). Each of these cranes returned to the same general summer area in subsequent years. Unlike the cranes in the 1980s, nearly 3 decades later cranes from these areas wintered throughout the migration route from Indiana to Florida (Figs. 2 and 3). This was very similar to the general winter range of the entire Eastern Population of greater sandhill cranes obtained from the state inquiries (Fig. 3). However, none of these birds wintered in the major wintering areas in southern Georgia and northern Florida that had been used by Upper Michigan and Ontario cranes in the 1980s (Fig. 2).

Hiwassee Wildlife Refuge (Tennessee), Wheeler NWR (Alabama), both on the Tennessee River, and more recently Muscatatuck NWR (Indiana), are the 3 largest current winter areas outside of Florida. These areas have consistently peaked at >10,000 cranes each winter since 2001 (Aborn 2010), 2012 (W. Gates, U.S. Fish and Wildlife Service, unpublished data), and 2016 (S. Baxter, U.S. Fish and Wildlife Service, unpublished data), respectively. No current estimates of numbers of greater sandhill cranes wintering in Florida are available.

DISCUSSION

Winter distribution 1985-1988

An adequate sample of uniquely marked individuals is necessary to obtain an accurate representation of distribution and fidelity to wintering sites for a given population. For samples that are small relative to the size of the population, finding all or almost of all of the marked individuals, as in the 1980s study reported here, was needed and accomplished. Because of the great differences in access and visual observability (e.g., low in northern swamps, high in central Florida cattle pastures) for this population, use of radiotagged cranes, rather than merely individually color-marked birds, was critical to unbiased ascertainment of winter distribution. Before this 1980s study and the later

Table 4. Winter areas of subadult sandhill cranes originally color-marked (not radiotagged) as fledged juveniles on Seney National Wildlife Refuge, Michigan, 1984-1986. Cranes wintered with their parents as juveniles. All sites are in Florida.

Sex-ID	Winter[a]				Parental co-occurrence after first winter
	1st	2nd	3rd	4th	
F-1	A[a]	A	A		Same flock with parent
M-2	B[b]	--	A[c]		Associating with parent
M-3	--	--	C	C	Same flock with parents
M-4	D	D			Same flock with parents
M-5	A	A			Parent wintered elsewhere both years

[a] Sites: A = Evinston, W. Marion Co.; B = Levys and Fowlers Prairie, Putnam Co.; C = Rollins Ranch, Indian River Co.; D = Citra muck farms, Alachua and Marion Cos.

[b] Wintering area of parent; probable but unconfirmed location of juvenile.

[c] Site A is in the same region and only 28 km from Site B (Table 1).

Table 5. Winter areas of sandhill cranes summering in Upper Michigan and along the North Channel of Lake Huron, Ontario, 2011-2014 (data from Fronczak et al. 2017). Locations are included in Figs. 2 and 3. For a bird that wintered in 2 different areas in the same winter, a value of 0.5 was assigned for no. of bird-winters in each area.

Summer location[a]	No. birds	No. bird-summers[a]	No.bird-winters	Winter areas (no. bird-winters)	Winter state
Hiawatha NF[b] near Trout Lake	2	5	5	Hiwassee[c] (1), Yuchi[c] (1) Kissimmee[d] (3)	Tenn. Fla.
Rudyard-Pickford	2	6	6	Yuchi (2) Pasco (4)	Tenn. Fla.
St. Marys River	1	4	4	SE Okeechobee [e] (4)	Fla.
Thessalon	2	7	6	Cecilia (1) Hiwassee (5)	Ky. Tenn.
Manitoulin Island	9	26	21	LaPorte [f] (0.5), Jasper-Pulaski (2.5), Muscatatuck[g] (1) Hop-In[c] (1) Butler[h] (1) Florahome[i] (2), W Marion[i] (1), E Marion[i] (1), Pasco Dade City (1), Kissimmee[d] (1), S Lake Marion[d] (1), Blue Cypress (2) Istokpoga (1), EC Okeechobee[e] (3), Buckhead Ridge[e] (2)	Ind. Tenn. Ga. Fla.
Total	16	48	42	42	

[a] Each of the 16 cranes summered in the same general area in each year for which data were available.
[b] East Unit of Hiawatha National Forest.
[c] State Wildlife Refuges.
[d] In Green Swamp/Kissimmee area (Fig. 2).
[e] In Lake Istokpoga/Lower Kissimmee Prairie area (Fig. 2).
[f] Northeast of Jasper-Pulaski FWA, Ind. (Fig. 3).
[g] National Wildlife Refuge.
[h] West-central Ga. (Fig. 3).
[i] In Paynes Prarie/Putnam Co. area (Fig. 2).

advent of remote tracking technologies (satellite, cellular, GPS), such work was minimal. Toepfer and Crete (1979) located 13 of 14 cranes VHF-radiotagged in Minnesota and Wisconsin in Florida during winter 1977-78; among these birds, they determined the winter distribution of 8 of 9 cranes from a common breeding/staging area in northwestern Wisconsin/central Minnesota and an additional 5 cranes radiotagged in central Wisconsin by Melvin (1977). Results during the following winter were limited to location of 1 pair of the radiotagged cranes from northwestern Wisconsin and a single crane from central Wisconsin (Anderson et al. 1980). Both Toepfer and Crete's study and the study of Upper Michigan and Ontario cranes in the 1980s presented here (Urbanek et al. 1988, Urbanek 1988) were successful in finding the marked cranes even though they were dependent on tracking by field personnel using VHF telemetry. Though much more labor-intensive than satellite and cellular tracking, this method in conjunction with visual observations yielded far more insight into bird behaviors, pairings and other associations, and habitat use by radiotagged cranes as well as by cranes that were color-banded only or not marked.

The widespread but clustered winter distribution of cranes from a common staging or breeding area found by Toepfer and Crete (1979) was confirmed in this study. The data from this study do not lend much support to the suggestion that cranes from the Upper Great Lakes wintered principally in south-central Florida (Nesbitt and Williams 1979). However, while the winter distribution of all Upper Michigan cranes was widespread across that of the entire Eastern Population, approximately 50% of cranes with summer territories on eastern Seney NWR (Fig. 4) wintered in 1 general area (near Blue Cypress Lake, Florida, Table 2). Therefore,

cranes from a specific portion (10,000-20,000 ha) of a larger breeding area might winter disproportionately in 1 area. This tendency could result because migratory routes and wintering areas are learned, and birds in a localized breeding area may have a significant degree of common ancestry. Winter data were available for 5 young cranes that had been color-banded as juveniles but not radiotagged. Each of these cranes returned to the parental wintering area or the area of first wintering in a subsequent year (Table 4).

The Upper Peninsula cranes demonstrated high winter site fidelity—85% from year to year in 1985-1988. A female apparently changed sites because of loss of her mate, pairing with another male, and then loss of that mate. The changes by males appeared due primarily to habitat conditions or disturbance. For example, a housing development was begun at Levys Prairie, Putnam County, in 1986. Crane 262 shifted his primary activity area 5 km southwest to Fowlers Prairie the next year, and wintered 28 km away in the following year. Wenner and Nesbitt (1987) also observed that changes in habitat conditions resulted in changes in use of Paynes Prairie by the same birds in subsequent years. Some infidelity to site could be expected on the basis of unusual behavior. Anderson et al. (1980) noted that a mated pair that wintered in south-central Florida in 1 year separated the next, the male wintering at Orange Grove Lake Prairie in north-central Florida and the female returning with their chick to the PWA of the previous year. The adult pair rejoined at Jasper-Pulaski FWA in the spring. In this study, mated Upper Peninsula pairs that were both marked were always observed together on the wintering grounds.

An additional 38 sandhill cranes were radiotagged on Seney NWR in 1988-1990; these were juveniles that were costume-reared and then gentle-released in autumn on or near Seney NWR in an experiment to develop reintroduction techniques (Urbanek and Bookhout 1992*b*). Although released into the wild population, several separated from wild cranes and wintered at atypical locations north of the major population winter areas during their first migration (Urbanek 1990). In subsequent migrations most of those individuals, as well as the other juveniles from their first migration onward, followed wild cranes farther south to winter in southern Georgia and Florida. However, without parents to lead them to specific traditional wintering areas, their winter distribution was skewed toward the northern part of that range (Urbanek and Bookhout 1994).

Comparison of Migration Routes between Upper Michigan and Ontario Cranes

Sandhill cranes were uncommon and little known along the North Channel of Lake Huron, Ontario, before 1960 (Urbanek 1988). Cranes later inhabiting this area were likely an eastern expansion of the population in Upper Michigan (Tebbel 1981). All cranes marked on Seney NWR have migrated through Wisconsin en route to Jasper-Pulaski FWA, Indiana (McMillen et al. 1991; R. P. Urbanek, unpublished data). Jasper-Pulaski FWA is also the major autumn stopover area for this Ontario segment of the population. During autumn migration, cranes from along the North Channel used the Rudyard-Pickford staging area in the eastern Upper Peninsula of Michigan (Fig. 1). Cranes from Ontario used routes through both Wisconsin and the Lower Peninsula of Michigan (i.e., both sides of Lake Michigan) when migrating between Ontario and Jasper-Pulaski FWA. Some of the same cranes used both routes in different migrations (Urbanek 1988, Fronczak et al. 2017). Major spring stopover areas consisted of Jasper-Pulaski FWA and traditional areas in east-central Wisconsin. Although most Ontario cranes migrated through the Lower Peninsula of Michigan, the migration routes of Upper Michigan and Ontario cranes were otherwise similar with use of the same staging, stopover, and winter areas.

Comparison of Winter Distributions in 1980s and 2010s

Winter distribution of the sandhill cranes radiotagged by Hanna (2017) and Fronczak (2014) and that summered in Upper Michigan and along the North Channel of Lake Huron was similar to that used by the Eastern Population of greater sandhill cranes as a whole (Fig. 3). The sample size was too limiting to ascertain if cranes originating in these areas had any preference for winter region. However, none of these cranes wintered in southern Georgia and northern Florida (Fig. 2). In addition to small sample size, cranes wintering in these areas, especially in the Okefenokee region, often occur in swamp openings that are inaccessible for ground observation. The state inquiry confirmed that there have been no regular aerial surveys to locate and count wintering cranes in recent years; therefore, current wintering status of the sandhill crane population in these areas is poorly known.

The main change in winter distribution of Upper Michigan and Ontario cranes, as well as of the entire population, that has occurred during the past 30 years is wintering farther north along the migration route. This has resulted from expansion of the population and greater reliance on waste corn as a primary food throughout the current winter range. For example, the winter concentration of cranes at Hiwassee Wildlife Refuge, Tennessee, began in the 1990s in response to planting of corn on the area (Aborn 2010). Winter areas north of Florida are limited by distribution of water and therefore available roost sites. Typically, these areas consist of a roost area on a managed public wildlife area surrounded by private crop fields. Since the 1990s, Jasper-Pulaski FWA (Fig. 3), the major migration stopover area of the Eastern Population of greater sandhill cranes, has become the northernmost major winter area of the population. This area freezes during an average winter. Although many wintering cranes may roost on frozen pool surfaces within the area, thousands have accommodated by roosting in a heated power plant reservoir 7 km northwest of the wildlife area wetlands. However, amount of snow covering waste corn in local fields is likely a more critical potential limiting factor to wintering at northern locations.

Many sandhill cranes of the Eastern Population still migrate to central Florida to winter (Urbanek et al. 2014) despite an exploding human population and resulting continued loss of habitat in that region. This is not a simple loss of wetland area but includes the loss of all types of habitat used by sandhill cranes for feeding (e.g., grasslands, cattle pastures, cornfields) and disturbance from encroachment by human development right up to the wetland margins (Nesbitt and Hatchitt 2008; R. P. Urbanek, personal observations). However, exact numbers, proportion of the total population, and complete current distribution of wintering cranes have not been documented. Cranes have either moved to the limited remaining habitats, become more tolerant of human activity, or in some cases wintered on restored wetlands. Because of greater historical as well as current abundance and widespread distribution of wetlands in Florida than in states farther north, many cranes in Florida continue to winter on private lands. However, crane use of public wetlands may increase as remaining habitat on private lands continues to be lost to development (Dahl 2005, Nesbitt and Hatchitt 2008).

Data Issues

Other than the study by Fronczak et al. (2017), there have been no large-scale studies of migration and wintering of the Eastern Population of greater sandhill cranes since those of Upper Michigan and Ontario cranes by the former Ohio Cooperative Fish and Wildlife Research Unit in the 1980s and early 1990s (McMillen 1988, Urbanek 1988, Urbanek et al. 1988, Urbanek and Bookhout 1994). The sample size of cranes from Upper Michigan and Ontario in the 2010s that was satellite-tracked by Fronczak et al. (2017) was small (16 birds). Of those, 7 birds were captured on migration or winter areas (not breeding areas); therefore, fidelity to those areas may have biased estimates of winter distribution of the Eastern Population.

In addition, although cranes in this study were from summer areas of similar latitude, the 1980s data were heavily weighted toward the western end of the breeding area. Most of those cranes originated from Seney NWR, whereas the 2010s data were mainly from cranes originating in the eastern end of the area on Manitoulin Island, 350 km away. None of the more recent data included cranes originating from Seney NWR (Fig. 1).

The survey by inquiry of authorities in states along the migration route worked well outside the historical primary wintering areas in southern Georgia and peninsular Florida. However, coverage within states was variable and some data were difficult to interpret. In Louisiana 2 possible winter areas were identified; however, Cheneyville in the central part of the state appeared to support <500 cranes during the past several winters. The other area, Holmwood (Fig. 3), supported a few thousand cranes, but these may have included cranes from the Mid-Continent Population, which are also known to winter in that area (King et al. 2010). Large flocks have been reported at other locations, e.g., in northern Mississippi (N. Winstead, Mississippi Department of Wildlife, Fisheries, and Parks, personal communication), but data indicating consistent recent winter congregations are not available. Thousands of cranes passed through other sites, e.g., Goose Pond Fish and Wildlife Area (unlabeled point in southwestern Indiana, Fig. 3), during migration. Although some of these stopover areas were used for several weeks, in general few or no sandhill cranes remained throughout the entire winter. There has been much variability in water

conditions at this site, but during a typical winter most water is frozen.

A record count of 32,600 birds occurred at Jasper-Pulaski FWA in fall 1991 (Castrale and Bergens 2001) when an unusual weather pattern resulted in almost all cranes that normally pass through that site being present there at the same time (Urbanek 1991). This count included nearly all of the cranes then present in the Eastern Population except for a few thousand that breed and stage at a few sites in Lower Michigan and do not pass through Jasper-Pulaski FWA on migration (Urbanek 1988). The weekly autumn counts at Jasper-Pulaski FWA are highly accurate because the roosting areas are relatively small and can be completely surrounded by the observers as they count the cranes flying out to feed in surrounding farm fields at daybreak. Counts at other staging and migration areas are on a voluntary basis with less stringent or practical controls; in addition, many areas containing cranes are not surveyed at all. Therefore, the peak count of the concentrated flock at Jasper-Pulaski in fall 1991 was a primary contributor to the last highly accurate count of the total Eastern Population. Since that time, data from the fall count coordinated by the U.S. Fish and Wildlife Service indicate that the population may have tripled in size (Dubovsky 2017). The population has increased in geographic range, and the beginning of fall migration has become extended over a longer period. To accommodate this change, an additional later counting period has been implemented to provide more accurate counts (Gillet 2016). However, movement of many more cranes through space and time is much more variable than 30 years earlier, and there is no simple means to accurately measure or estimate numbers in the entire population.

Other Potential Data Sources

Other data sources are available but do not readily provide data needed to define winter distribution. For example, the annual Audubon Christmas Bird Count consists of counts by volunteers in predefined 24-km-diameter circles from mid-December through the first week of January. All areas occupied by cranes are not covered, and as progression of autumn migration has become later (Gillet 2016, Fronczak et al. 2017) during the past 30 years, large numbers of cranes are still in migration at the time of the Christmas counts, including many remaining as far north as Wisconsin and Lower Michigan (Lacy et al. 2015). Cornell Lab of Ornithology's eBird is another volunteer-based source, but data reporting follows no systematic protocol, is inconsistent in time and space, and often does not provide accurate numbers of common species in large flocks. However, some data on location of large flocks, composed mainly of wintering greater sandhill cranes, could possibly be extracted from this source. Crane counts in Florida and southern Georgia are complicated by presence of non-migratory Florida sandhill cranes (*G. c. pratensis*). The latter population was estimated at 4,594 individuals and declining in Florida in 2003 (Nesbitt and Hatchitt 2008). However, Florida sandhill cranes do not occur in large flocks typical of most wintering greater sandhill cranes. Surveys of wintering cranes in the historic winter range in Florida and southern Georgia would be more difficult than counts in the northern range expansion because of greater dispersion of cranes among sites which are less accessible to observers or support smaller numbers.

MANAGEMENT IMPLICATIONS

Development of a management plan for the Eastern Population of greater sandhill cranes (Van Horn et al. 2010) opened opportunity for individual states to establish hunting seasons, and this has already occurred in Kentucky and Tennessee beginning in winters 2011-12 and 2014-15, respectively (Dubovsky 2017). Both wintering and fall migrating cranes were affected. The lack of current repeatable measures, even on total numbers in the Eastern Population, underscores the need for further study. In addition to counts on migration staging and stopover areas, turnover rate, which requires data for individual birds, would be a useful measurement, especially because not all occupied sites are adequately surveyed during the roughly simultaneous fall counts. Enumeration of the winter distribution of the population across its entire geographic span also needs study, especially in Florida, where large numbers of cranes, dispersed across many sites, continue to winter but for which current distribution has not been recently documented and evaluated. Although the population has grown significantly during recent decades, availability of future roosting and feeding habitat across the winter range needs to be determined and evaluated to manage the population and secure its future.

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