The Use of Satellite Telemetry to Evaluate Migration Chronology and Breeding, Migratory, and Wintering Distribution of Eastern Population of Sandhill Cranes[1]

2012 Annual Report

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Abstract: The Eastern Population (EP) of sandhill cranes (*Grus canadensis*) is rapidly expanding in size and geographic range. The core of their breeding range occurs in Wisconsin, Michigan, and southern Ontario; however, the EP range has expanded in all directions as the population has grown. Little is known about the geographic extent of breeding, migration, and wintering ranges of EP cranes, or migration chronology and use of staging areas. In December of 2009, we began trapping and attaching solar Global Positioning System (GPS) satellite Platform Transmitting Terminals (PTT) on EP sandhill cranes to assess movements throughout the year. We continued trapping throughout the spring and fall of 2010, the winter of 2010-2011, the fall of 2011 and winter of 2011-2012. To date, we have rocket-net trapped and attached PTTs (n = 30) to cranes in Indiana: Goose Ponds Fish and Wildlife Area (FWA), Greene County and Jasper-Pulaski FWA, Jasper and Pulaski Counties; Minnesota: Sherburne National Wildlife Refuge (NWR), Sherburne County; Tennessee: Hiwassee Wildlife Refuge, Meigs County and Hop-IN Wildlife Refuge, Obion County; and Wisconsin: Crex Meadows Wildlife Area, Burnett County. Location data for these birds are currently being received from Collecte Localisation Satellites (CLS) America Inc., Maryland, translated by software developed by NorthStar Science and Technology LLC, Maryland, and viewed using Environment System Research Institute (ESRI) ArcGIS software.

Introduction

The Mississippi and Atlantic Flyway Councils endorsed a management plan for the Eastern Population (EP) of sandhill cranes (*Grus canadensis*) due to their increasing population. The plan's stated goal is to manage EP cranes in the Mississippi and Atlantic Flyways at a sustainable population level that is consistent with habitat and societal values (Van Horn et al. 2010). The main objectives of the plan include:

1. Maintain the population index between 30,000-60,000 cranes as measured by the U.S. Fish and Wildlife Service (USFWS) Coordinated Fall Survey.

2. Reduce agricultural damage and conflicts due to EP cranes.
3. Provide non-consumptive opportunities
4. Provide consumptive opportunities.

Objective One of the management plan states that the population status will be monitored by the fall sandhill crane survey coordinated by the USFWS. The fall survey is a long-term annual survey, established in 1979. It consists of efforts by volunteers and state and federal agencies from the Atlantic and Mississippi Flyways (Wisconsin, Michigan, Indiana, Tennessee, Georgia, and Florida). The main goal of the survey is to count EP cranes that concentrate in Indiana, Michigan, and Wisconsin. The survey is also timed to count birds migrating from the Manitoulin Island staging area in northern Lake Huron, Ontario (Van Horn et al. 2010). The 2012 fall survey resulted in a population index of approximately 87,800 with a five-year average (2008-2012) of 62,700 (Fig. 1).

Early observation records indicate that EP cranes formerly bred across the Great Lakes region (Michigan, Ontario, and Wisconsin) and wintered in Florida and southern Georgia (Walkinshaw 1960). However, the extent of the breeding range in Ontario is unclear. Observation records also indicate that EP cranes migrate southward from their breeding grounds through an east-central corridor that includes Illinois, Indiana, Ohio, Kentucky, Tennessee, and Alabama, enroute to wintering grounds in southern Georgia and central Florida (Walkinshaw 1973, Lewis 1977, Tacha et al. 1992, Meine and Archibald 1996).

EP cranes appear to be expanding their traditional breeding range and migration routes. A 1977-1979 cooperative inventory of sandhill cranes in Minnesota observed breeding pairs, young, and non-breeding sandhill cranes in northwest and east-central counties during the months of May through August. Those cranes observed in east-central Minnesota were considered a part of the EP (Henderson 1979). Since the late 1970s, the breeding range has expanded to the south and now includes northern Iowa, Illinois, Indiana, and Ohio (Tacha et al. 1992; David Sherman, Ohio Department of Natural Resources, pers. com.).

Recent advancements in technology allow a better examination of sandhill crane movements than was previously possible. For example, in 2007, 6 Platform Transmitting Terminals (PTTs) were placed on sandhill cranes in north-central and southwest Louisiana (Sammy King, U.S. Geological Survey [USGS] Louisiana Cooperative Fish and Wildlife Research Unit 2007). Two of the 6 marked birds migrated east of the Mississippi River into the EP range. The remainder migrated west of the Mississippi River into the Mid-Continent Population (MCP) range, suggesting mixing between the EP and MCP in Louisiana. Of the 2 birds that migrated east of the Mississippi River, 1 migrated through a less traditional route of west Tennessee through Illinois and into Wisconsin. That same year, Long Point Waterfowl – Bird Studies, Canada placed 4 PTTs on EP sandhill cranes on the north shore of Lake Ontario, Canada and described cranes using traditional migration routes and breeding and wintering areas (Long Point Waterfowl - Bird Studies Canada 2009).

In 2009, the Association of Fish and Wildlife Agencies' Migratory Game Bird (MGB) Support Task Force composed of U. S. and Canadian academic, state/provincial, and federal agency experts met to identify priority information needs for the 6 migratory populations of sandhill cranes. These priority needs focused on initiating or enhancing monitoring efforts and estimating vital rates during the annual cycle of sandhill cranes (D. J. Case and Associates 2009). Reviewing the main objectives of the EP management plan and available EP crane studies, the MGB Support Task Force identified 2 primary information needs for EP cranes:

1. Describe the geographic extents of the breeding and wintering range. Document the spatial and temporal aspects of migration and make appropriate suggestions towards improving the design of the USFWS coordinated survey that will reflect current distribution and migration patterns.

2. Conduct a critical review of the current USFWS coordinated survey and evaluate its effectiveness to monitor the population, recommend improvements for the survey, and develop a standard survey protocol.

The objectives of our study are to address the first information priority need for EP cranes identified by the MGB Support Task Force. We will describe the EP breeding and wintering range and migration by trapping sandhill cranes with rocket-propelled nets on major staging grounds and placing solar GPS PTTs on 30 EP sandhill cranes. We will trap EP sandhill cranes at the Jasper-Pulaski FWA during the fall months of October and November and then at the Hiwassee Wildlife Refuge, Tennessee during the winter months of December and January, 2010-2011.

Study Area

We trapped and placed the majority of the PTTs (*n* = 21) on sandhill cranes staging at Jasper-Pulaski Fish and Wildlife Area (FWA), Jasper, Pulaski, and Starke Counties, Indiana and at the Hiwassee Wildlife Refuge, Armstrong and Blythe's Ferry Units, Meigs County, Tennessee (Fig. 2). The Jasper-Pulaski FWA encompasses 3,263 ha and is located in northwest Indiana within the Kankakee Outwash and Lacustrine Plain physiographic region. Small dunes and low marsh lands dominate the area as a result of the retreat of the Saginaw Lobe of the Wisconsin Glacier. The land use surrounding JP is predominantly agriculture, particularly corn and soy bean production. Land use on the Jasper-Pulaski FWA is approximately 810 ha of wetland, shallow aquatic impoundments, and upland comprised of 2,023 ha of woodlands (*Quercus* spp. dominate) and 405 ha of upland/cropland. Crops produced for wildlife include corn, soybeans, and winter wheat. Hunting wildlife is allowed in designated zones within the Jasper-Pulaski FWA. However, protection zones are incorporated within the Jasper-Pulaski FWA for crane roosting, feeding, and loafing (Indiana Department of Natural Resources internal report, unpublished).

Hiwassee Wildlife Refuge is located in eastern Tennessee within the Southern Ridge and Valley Physiographic System 13 (Partners In Flight: Physiographic Area Plan, 2010) and the tablelands of the Southern Cumberland Plateau. The most abundant land-cover types are oak-hickory or oak-pine mesophytic forest, with scattered agricultural fields comprising a low proportion of the total landscape. The Hiwassee Wildlife Refuge encompasses approximately 2,428 ha (1,112 ha land and 1,416 ha water) located within the Chickamauga Reservoir at the confluence of the Hiwassee and Tennessee Rivers. Included are 162 ha of Hiwassee Island. Land use is approximately 30% agricultural and is cropped and 70% is a wooded mix, primarily of pine and hardwood forest. Crops produced for wildlife consumption include corn, winter wheat, soybeans, milo, varieties of millet, and buckwheat (Tennessee Wildlife Resource Agency, Important Bird Areas 2006). Adjacent sand bars and low water levels on Chickamauga Lake create ideal roosting habitat for waterfowl and sandhill cranes during the fall and winter months. The refuge is managed to provide habitat for wildlife, specifically wintering waterfowl.

In addition, we trapped and placed PTTs (*n* = 5) on EP cranes at Goose Ponds FWA, Greene County, Indiana during the 2010 spring migration, the Sherburne NWR, Sherburne County, Minnesota during the 2010 fall migration, the Crex Meadows Wildlife Area, Burnett County, Wisconsin during the 2011 fall migration, and the Hop-In Wildlife Refuge, Obion County, Tennessee during the 2011 winter (Fig. 2). EP sandhill cranes stage and winter at these areas, however neither area has concentrations of cranes as large as at either Jasper–Pulaski FWA or Hiwassee Wildlife Refuge.

The Goose Pond FWA was established by the Indiana Department of Natural Resources in 2005 and is described as a glacial wetland within the White River Drainage Basin that lies in the Ohio Ecosystem (Indiana Department of Natural Resources 2011). Goose Pond FWA is approximately 3,258 ha and 60% of the land use consists of herbaceous marsh, wet meadows, and open water. Migrating cranes roost along shallow wetlands on the property and feed in the adjacent agriculture land that include corn, soybeans, and winter wheat production. A peak estimate of 11,000 cranes was observed during an evening feeding flight in March 2010 (Brad Fiester, Indiana Department of Natural Resources, pers. com.).

The Sherburne NWR is located in the Mississippi Headwaters/Tall Grass Prairie Ecosystem in east-central Minnesota and encompasses approximately 12,373 ha (2,959 ha water and 9,378 ha land). Refuge wetlands provide suitable nesting habitat for approximately 30-40 nesting pairs of EP cranes annually and are preferred for roosting habitat for an estimated 2,500-3,500 migrating cranes during the fall. Land use to the north, west, and northeast of Sherburne NWR is predominantly agriculture and includes corn, soybeans, and cattle pasture that provide food resources for migrating cranes (USFWS, Sherburne NWR Comprehensive Conservation Plan, 2005).

The Crex Meadows Wildlife Area is located within the remaining Northwest Wisconsin Pine Barrens and is approximately 12,040 ha in size consisting of interspersions of

brush prairie, oak-jack pine forest, and an extensive sedge marsh, which was once the Glacial Lake Grantsburg (Crex Meadows Wildlife Area, Wisconsin Department of Natural Resources 2012). Crex Meadows has an increasing number of breeding pairs within the sedge marsh. However, the largest numbers of birds are seen during the period of fall migration. Recent accounts indicate that approximately 7,000 EP cranes use Crex Meadows Wildlife Area and the surrounding agricultural fields while staging prior to the fall migration (Steve Hoffman, Wisconsin Department of Natural Resources, pers. com.).

The Hop-In Wildlife Refuge is managed by the Tennessee Wildlife Resource Agency and is a part of the J. Clark Akers Wildlife Complex within the Mississippi Valley Loess Plains Ecoregion [Tennessee Wildlife Resource Agency, Obion (South Fork) Watershed 2008]. The Hop-In Wildlife Refuge unit is 251 ha in size and provides roosting habitat within the moist soil units that were created for wintering waterfowl. The surrounding agriculture land (winter wheat, corn, soybeans) offers winter foraging for an average of 1,500-2,000 cranes (Tennessee Wildlife Resource Agency, Important Bird Areas, 2008).

Methods

We used rocket-propelled nets as the primary method to trap EP sandhill cranes within the Jasper-Pulaski FWA and Hiwassee Wildlife Refuge during the fall and winter months. We began by identifying daytime loafing sites by observing crane movements, and baiting loafing sites with whole corn. We used the protocol for identifying potential trapping sites developed for rocket-propelled netting MCP cranes (Krapu et al. 2011), giving priority to loafing sites with >20 cranes present in pasture or other open land-cover types. When cranes responded to bait for 2 consecutive days, we assembled a rocket net trap as described by Wheeler and Lewis (1972) and David Brandt (USGS Northern Prairie Wildlife Research Center, pers. com.).

We primarily conducted trapping in the morning because cranes consistently return to these sites after leaving nocturnal roosts. Following capture, we isolated a single crane and placed it in a canvas handling bag as part of the process of receiving a PTT. If possible, we identified and affixed a transmitter to an adult female sandhill crane that was observed as part of a family group or as a member of a male-female pair. However, if family groups were not identifiable, we isolated a smaller-bodied, adult crane (presumed to be a female—sex will be determined via genetic analysis of blood). We identified adult females based on red skin on the crown of the head, smaller body size, and social behavior among birds (David Brandt, USGS Northern Prairie Wildlife Research Center and Ann Lacy, International Crane Foundation, pers. com.).

For each bird to which we affixed a PTT, we collected morphological measurements as described by Dzubin and Cooch (1992), and drew blood, which was placed in a Lysis buffer anticoagulant solution and used to determine sex of the bird at a later time (Jones 2005). We affixed a 7.6 cm, 30 g, solar-powered GPS satellite PTT (North Star Science and Technology, Maryland) to the distal tibio-tarsus above the joint (Dave Brandt,

USGS Northern Prairie Wildlife Research Center, pers. com.) to cranes identified as part of our marked sample. Other cranes captured were affixed with a 7.6-cm color-coated, alpha-numeric coded tarsus auxiliary leg band. All birds captured received a USGS, Bird Banding Laboratory (BBL) size 8, 1-800, aluminum, butt-end band and were released as a group.

In addition to using rocket-propelled nets, we used a Coda NetLauncher to capture cranes where using a rocket net was not feasible. We followed the protocol for standard use of the Coda NetLauncher that was developed by the Ohio Department of Natural Resources during their 2010 nesting sandhill crane study in Ohio (Dave Sherman, Ohio Department of Natural Resources, unpublished). We also used modified Victor #3 softcatch leghold traps as described by King and Paulson (1998) to capture 1 crane.

Data: We will describe EP sandhill crane migration staging areas, routes, and chronology by analyzing satellite data from 30 cranes captured during fall migration. Satellite data will consist of 5 GPS locations per day during spring and fall migration (October – May) and 4 GPS locations per day during the summer months (June – September). In addition, PTTs will transmit standard ARGOS satellite system estimated Doppler locations and diagnostic data every 3 days for an 8-hour period. Doppler locations will be filtered to obtain reliable locations using the Douglas ARGOS-Filter Algorithm developed by Dave Douglas (USGS, Anchorage, AK, USA) (Krapu, USGS Northern Prairie Wildlife Research Center, in press).

We will download satellite data every 2 days from the CLS America, Inc. website. Data will be translated by software developed by NorthStar Science and Technology LLC, viewed using ESRI ArcGIS software (2009), and maintained in a database of location and sensor data as a GIS shapefile. We will use ArcGIS (ESRI, Redlands, CA, USA) to analyze satellite data to estimate migration departure dates, distance between stopovers, frequency of stopovers, duration of stay at a stopover, and total distance of spring and fall migration, similar to the analysis described in Krapu et al.'s (2011) satellite study of MCP cranes and described in the mallard (*Anas playtrhynchos*) studies by Yamaguchi et al. (2008) and Krementz (2012). Breeding and wintering grounds for tagged EP cranes will be defined by the geographic terminus of migration as in Krapu et al. (2011).

Timeline: Satellite data will continue to be collected through the CLS America satellite system's website, processed through a satellite decoding program created by North Star Science and Technologies LLC, and analyzed throughout 2012 and 2013.

Results

To date, we captured and marked 30 EP cranes with PTTs during the spring and fall migration and the winter months of 2009 through 2012. We initiated a pilot project during the months of December 2009 and January 2010 and marked 6 EP sandhill

cranes on the Armstrong and Blythe's Ferry Units, Hiwassee Wildlife Refuge. In addition, we marked 1 crane in March 2010 at Goose Pond FWA, Indiana. After the pilot project was completed, we analyzed preliminary satellite movements and evaluated the previous trapping events. We determined that we would complete the field work by trapping during the initial and peak arrival dates at JP during fall of 2010 and at Hiwassee Wildlife Refuge during winter of 2010-2011, to better describe the spatial and temporal aspects of EP crane migration.

We continued the project in the fall of 2010 by marking 1 crane at Sherburne NWR, Minnesota prior to the anticipated trapping schedule to assure representation for the northwest extent of the EP range. We then marked 4 cranes at Jasper-Pulaski FWA in late October 2010 and 3 cranes in late November 2010. We continued trapping and marked 6 cranes at Hiwassee Wildlife Refuge in early December 2010. We concluded marking birds by trapping 1 EP crane during the fall staging period of 2011 at Crex Meadows Wildlife Area, Wisconsin, and by trapping 2 cranes during winter 2011-2012 at the Hop-In Wildlife Refuge, Tennessee and 2 cranes that winter at Hiwassee Wildlife Refuge, Tennessee.

In total, throughout our trapping effort, we captured approximately 190 sandhill cranes. We caught 178 EP cranes with rocket nets, 11 with the Coda NetLauncher, and 1 with a softcatch leghold trap. We fitted 61 EP cranes with a 1-800 aluminum federal band and a 7.6-cm, black-with-white lettering, 3-digit alpha-numeric coded tarsus auxiliary band. We fitted 30 EP cranes with an 80-g, 7.6-cm, single black-with-white lettering, 2-digit alpha-numeric tarsus auxiliary band attached with a solar-powered GPS PTT and a 1-800 aluminum federal band. The remainder of sandhill cranes we caught received a 1-800 federal aluminum band.

Preliminary data analysis of GPS movement indicate that PTT-marked cranes returned to their summer territories using the traditional routes and staging areas as previously described (Appendix 1). The GPS points we received also indicate that of 23 cranes with active PTTs, 3 established territories in Minnesota, 9 settled throughout Wisconsin, 3 settled in Lower Michigan, 2 settled in the Upper Peninsula of Michigan, 3 settled on the north shore of Lake Huron, Ontario, Canada and 3 settled in north-central Ontario, Canada (Appendix 2).

To date, we are actively tracking 22 of the 30 marked cranes. Five marked birds that we fitted with PTTs subsequently died during the spring migration period and 1 PTT ceased to register a month after deployment. There was no effort to determine the cause of death for any of the recovered PTT-fitted birds due to the length of time between the recognition of a true sedentary position and PTT recovery. However, we recovered 4 of the 5 PTTs, tested, and then redeployed then in Tennessee, 2012. There were 3 mortalities due to trapping.

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Literature Cited

D. J. Case and Associates (editor). 2009. Priority information needs for sandhill cranes: a funding strategy. Developed for the Association of Fish and Wildlife Agencies by the Migratory Shore and Upland Game Bird Support Task Force. 13pp.

Dzubin, A. and E. Cooch. 1992: Measurement of geese: general field methods. California Waterfowl Association. Sacramento, California, USA. 20pp.

ESRI Inc. 2009. ESRI ArcGIS v9.3.1. ESRI Inc., Redlands, California, USA.

Indiana Department of Natural Resources, 2011. http://www.in.gov/dnr/fishwild/3094.htm. Accessed 12 January 2011.

Jones, K. L., G. L. Krapu, D. A. Brandt, and M. V. Ashley. 2005. Population genetic structure in migratory sandhill cranes and the role of Pleistocene glaciations. Molecular Ecology 14: 2645-2657.

King, D. T., J. D. Paulson, D. J. Leblanc, and K. Bruce. 1998. Two capture techniques for American white pelicans and great blue herons. Waterbirds 21:258-260.

Lewis, J. C., G.W. Archibald, R.C. Drewien, C.R. Frith, E.A. Gluesing, R.D. Klataske, C.D.Littlefield J.Sands, W.J.D. Stephen, and L.E. Williams Jr. 1977. Sandhill crane (*Grus canadensis*). Pages 5-43 in G.C. Sanderson (ed.). Management of migratory shore and upland game birds in North America. International Association of Fish and Wildlife Agencies. Washington, D.C., USA.

Meine, C. D. and G. W. Archibald (eds). 1996. The cranes:-status, survey, and conservation action plan. IUCN, Gland, Switzerland, and Cambridge, U.K. 294pp. Northern Prairie Wildlife Research Center Online. http://www.npwrc.usgs.gov/resource/birds/cranes/index.htm (Version 02MAR98). Accessed 29 January 2010.

SAS Institute Inc. 2002. SAS v9.1.3. SAS Institute, Cary, North Carolina, USA.

Partners In Flight. 2000. Southern Ridge and Valley, Physiographic Area – 13, Executive Summary. http://www.blm.gov/wildlife/pl_13sum.htm. Accessed 10 February 2010.

Sharp, D. E., K. L. Kruse, and J. A.Dubovsky. 2009. 2009 Status and harvests of sandhill cranes: Mid-Continent, Rocky Mountian, and Lower Colorado River Populations. Administrative Report, U. S. Fish and Wildlife Service, Denver, Colorado. 37 pp.

Tennessee Wildlife Resource Agency. 2006. Hiwassee Wildlife Refuge, Chickamauga Wildlife Management Area, Yuchi Refuge at Smith Bend and Environs. http://www.tnbirds.org/IBA/SitePages/Hiwasee.htm. Accessed 10 February 2010.

Tennessee Wildlife Resource Agency. 2008. Hop-In Wildlife Refuge. http://www.tnbirds.org/IBA/SitePages/Hop-InRefuge.htm. Accessed 15 January 2012.

U.S. Fish and Wildlife Service, 2005. Sherburne National Wildlife Service Comprehension Conservation Plan. U.S. Fish and Wildlife Service, Regional Office, Fort Snelling, Minn.

Van Horn, K., T. White, W. Atkins, T. Cooper, R. Urbanek, D. Holm, D. Sherman, D. Aborn, J. Suckow, K. Cleveland, R. Brook. 2010. Management Plan for the Eastern Population of Sandhill Cranes. Mississippi and Atlantic Flyway Council Webless Committee. 34pp.

Wheeler, R. H. and J. C. Lewis. 1972. Trapping techniques for sandhill crane studies in the Platte River Valley. U. S. Department of the Interior, U. S. Fish and Wildlife Service Natural Resource Publication 107. 19pp.

Wisconsin Department of Natural Resources. 2012. Friends of Crex Meadows Official Website. http://www.crexmeadows.org/index.html. Accessed 15 January 2012.

Yamaguchi, N., E. Hiraoka, M. Fujita, N. Hijikata, M. Ueta, K. Takagi, S. Konno, M. Okuyama, Y. Watanabe, Y. Osa, E. Morishita, K. Tokita, K. Umada, G. Fujita, and H. Higuchi. Spring migration routes of mallards (Anas platyrhynchos) that winter in Japan, determined from satellite telemetry. Zoological Science 25:875-881.

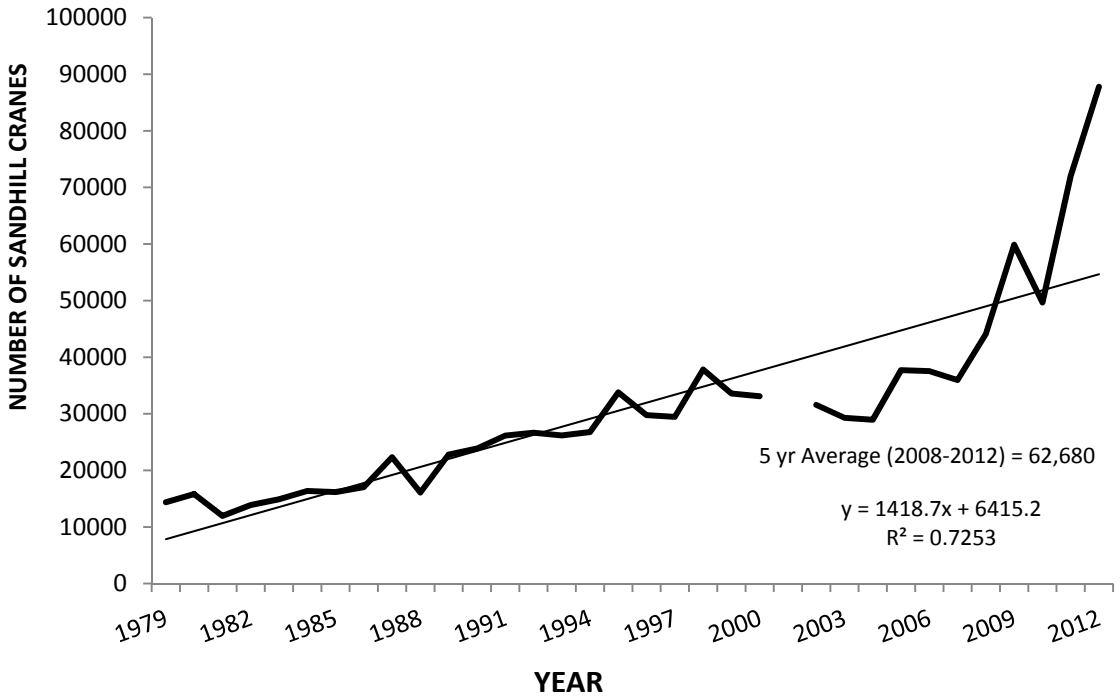
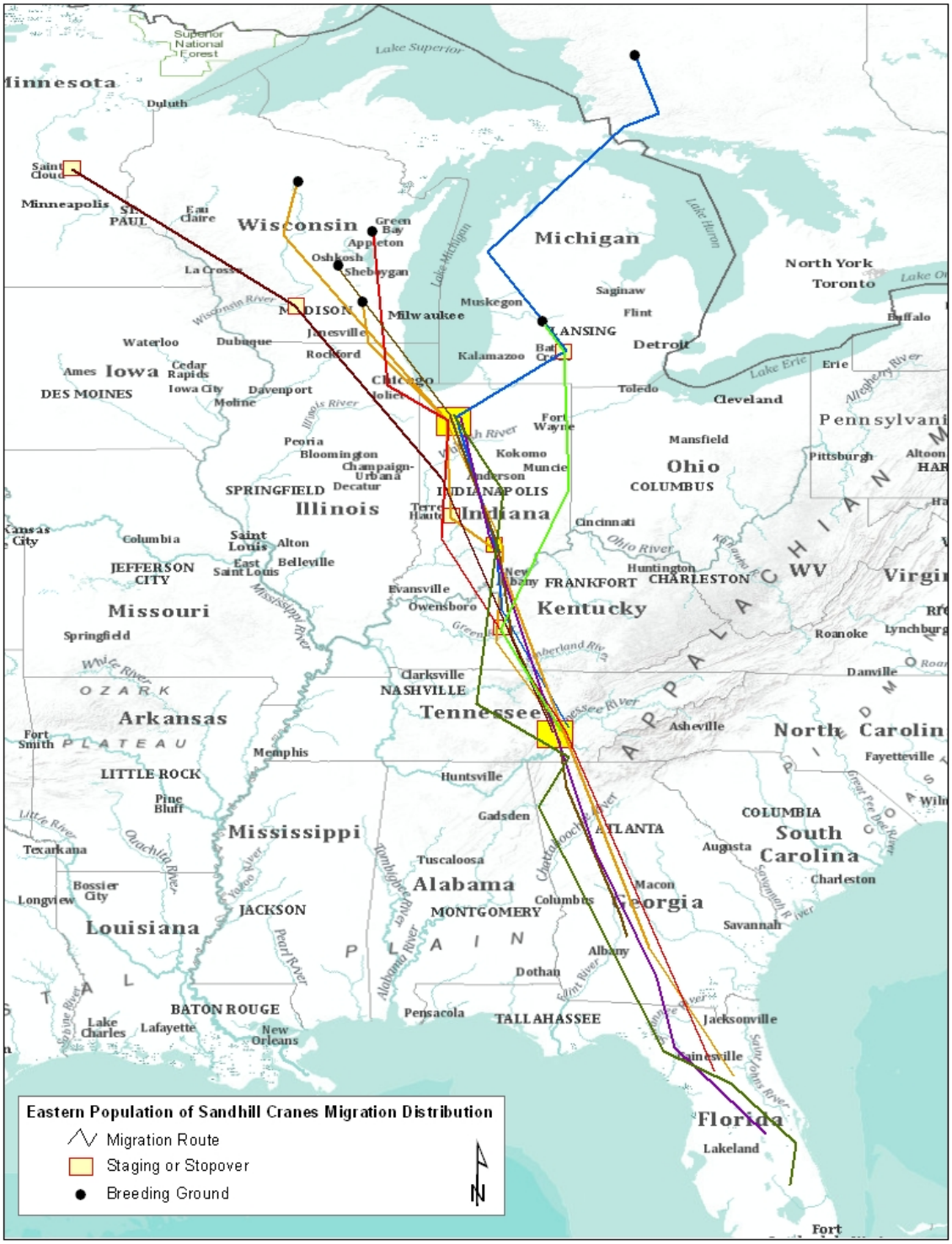


Figure 1. Number of Eastern Population sandhill cranes counted on fall surveys. Survey was not conducted in 2002. U.S. Fish and Wildlife Service data.

Figure 2. Eastern Population sandhill crane trapping locations in Indiana, Minnesota, Tennessee, and Wisconsin.

Appendix 1. Preliminary breeding and wintering areas, migration routes, and staging areas for Eastern Population of sandhill cranes, 2009-2010. Unpublished data, 2010.



Appendix 2. Breeding territories and winter areas for all PTT-marked Eastern Population of sandhill cranes, 2012. Unpublished data, 2013.