North American Trumpeter Swan Survey 2015

Minnesota

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Introduction

The North American Trumpeter Swan Survey is the official status assessment for this species. It was first conducted in 1968 and has been completed at five-year intervals since 1975 (Groves 2012). T he survey includes cooperators from federal, state, and provincial agencies across the northern United States and Canada, as well as volunteers from non-governmental organizations and the general public.

When trumpeter swans (*Cygnus buccinator*) were being reintroduced to Minnesota, collaborators knew the locations of most nesting pairs and counted known pairs as well as incidentally observed birds from the ground or air, or solicited observations from the public. As the population grew, this survey was conducted during winter months as it was believed that most of the population concentrated at a limited number of wintering locations in Minnesota. Beginning in 2015, the U.S. Fish and Wildlife Service has requested that current and future surveys be conducted during the breeding season. Swan observations have been recorded as part of the annual Waterfowl Breeding Population Survey conducted by Minnesota Department of Natural Resources (MNDNR), but few trumpeter swans were detected before 2000. T his survey provides an estimate of swans primarily in the prairie and transition zones of Minnesota. Swans have also been documented in the forest zone north and east of the Waterfowl Breeding Population Survey area (e.g., Minnesota Breeding Bird Atlas Project; http://www.mnbba.org/blockmap/cresults.php?species=Trumpeter Swan); however, the number of breeding swans in northeastern Minnesota is unknown.

The forest zone is vast with extensive remote areas, and information on habitat associations, availability, and geographic distribution was limited in this zone, which presented challenges for designing a reliable, cost-effective survey to estimate swan numbers here. T herefore, we developed and implemented a pilot aerial survey for breeding swans in northeastern Minnesota in the spring of 2015. Additionally, the metropolitan area around the cities of Minneapolis and St. Paul are not counted during the annual waterfowl survey. T he five county (Anoka, Hennepin, Ramsay Washington, Wright) metropolitan area was counted using aerial surveys and ground counts organized by staff in the Three Rivers Park District. T his report summarizes the results of the pilot breeding swan survey, and provides population estimates based on the pilot swan survey (2015), the Waterfowl Breeding Population Survey (2000-2015) and provides count data from the five county metropolitan area. -

Methods

Pilot Breeding Swan Survey

Given the lack of detailed information on swans in the northeast forest zone, we elected to conduct an extensive aerial transect survey to collect baseline data on the distribution of breeding swans and to identify potential habitat associations that could be used to improve the sampling design (e.g., via sampling-frame delineation or stratification). We divided the sampling frame into east-west transects that were 10-30 mi long and 0.25 mi wide. The choice of transect dimensions reflected anticipated tradeoffs among survey costs, efficiency, sample size (number of transects), obtaining a sample of counts greater than zero (for ratio estimation), and the spatial distribution of the sample. We then summarized Gap Analysis Program (GAP) data on open-water habitats (class 12 [water] and 13 [floating vegetation]) contained within each transect and used that information to stratify the sampling frame. For the pilot survey, we simply used the 1st and 3rd quantiles (25% and 75% of ordered observations) of total open-water habitat as breakpoints to form 3 strata denoting the relative amount of "potential" swan habitat in each transect (low, medium, high). We used the R package "spsurvey" (Kindaid and Olsen 2013; R Core Team 2014) and proportional allocation to draw a spatially balanced stratified sample of transects (ignoring differences in transect length). We chose a target sample size of 75 transects based on anticipated flight time and survey costs. Transects were 0.25-mi wide, but we collected swan observations up to 0.5 mi from the flight line to provide additional information that might aid in refining the survey design.

The survey was conducted using a Cessna 185 with an observer and pilot. Only the observer counted swans. The airplane traveled 0.25 miles north or south of the transect center line depending on the direction of flight, so that the observer could view the entire transect width (0.5 mi). Transects were flown at approximately 120 mph at 800-1000 feet above ground level. When birds were encountered that may be another species (e.g., American white pelicans [*Pelecanus erythrorhynchos*]), we descended to a lower altitude, and circled one or more times until accurate species information was obtained. We flew on days with good visibility and light winds. The survey was conducted in early May for consistency with data collection of the Waterfowl Breeding Population Survey.

Swan observations were recorded on a Toughbook® tablet using DNRSurvey moving-map software (ver. 2.11, an ArcGIS add-in developed by MNDNR Section of Wildlife and MN.IT Services). The pilot and observer could view 0.25 and 0.5 mi transect boundaries and aerial photography in real-time. As swans were observed, the observer touched the Toughbook in a similar place on an aerial photo; a global positioning system location was automatically collected and the observer recorded if the swan was single, paired, flocked (along with the number of swans in the flock) or if a nest was present.

Waterfowl Breeding Population Survey

The MNDNR Waterfowl Breeding Population Survey is a long-running annual survey that uses east-west aerial transects (0.25-mi wide) stratified by historic wetland/lake density (Figure 1). The survey is conducted using a fixed-wing aircraft and 2 observers (pilot and a primary observer) and

is seasonally timed to be optimal for breeding mallard (*Anas platyrhynchos*) ducks (although all waterfowl species are recorded). Standard procedures for the survey generally follow those outlined in "Standard Operating Procedures for Aerial Waterfowl Breeding Ground Populations and Habitat Surveys in North America" (USFWS/CWS 1987). The sampling design and survey protocols are briefly described in annual MNDNR reports (e.g., Cordts 2015). Since 2005, swan observations have been recorded by total count rather than by social category (single, flocked, etc.). Thus, we could not decompose the population estimate of swans by breeding status or social category.

Five County Metro Area Count

An aerial survey and counts of swans and nests were conducted by staff from Three Rivers Park District. Staff conducted flights by fixed-wing airplane in western metro counties and by helicopter in Ramsey, Washington, and Anoka counties. They visited water bodies that were known or believed to have swans. Swans found while flying among known sites were also recorded. The observer recorded the date, location and social category. Park District staff also solicited observations from citizens and asked citizens to report swans observed beginning 11 May 2015. Citizens provided the date, location of the observations, the number of swans and social category to Park District staff.

Analytical methods

We used a ratio estimator (Cochran 1977:150) to estimate the total number of swans in the stratified sampling frames, because transects varied in length (and thus area) in both the Pilot Breeding Swan and Waterfowl Breeding Population surveys. We used the R package "survey" (Lumley 2014, R Core Team 2014) to compute ratio-based estimates of population size and sampling variance. We explored both combined and separate ratio estimators (for stratified sampling designs). The estimators produced very similar population estimates in both surveys; therefore, we only report the results of the combined ratio estimator. For the Pilot Breeding Swan Survey, we calculated estimates for both 0.25 and 0.5- mi wide transects. The later estimates are ad hoc because the sampling frame was based on 0.25-mi wide transects; thus, inclusion probabilities for 0.5-mi wide transects reflected aerial coverage rather than random sampling. Nevertheless, it allowed us to compare the two transect widths in terms of sampling statistics and population estimates. We also reviewed past winter counts submitted to U.S. Fish and Wildlife Service and National Audubon Society Christmas Bird Counts (National Audubon Society 2010) for comparison to our first statewide breeding survey of trumpeter swans. Christmas Bird Count Data included states in the Mississippi Flyway only (Alabama, Arkansas, Iowa, Illinois, Indiana, Louisiana, Michigan, Minnesota, Missouri, Mississippi, Ohio, Tennessee, and Wisconsin). We do not know how many Minnesota breeding swans leave the state, nor do we know where they go. We assumed birds from Minnesota would either remain in Minnesota or migrate south primarily within this flyway.

Results

Pilot Breeding Swan Survey

Total acres of open-water habitats (GAP data) per transect ranged from 0 to 3,292 ac. The sampling frame consisted of 933 transects (0.25-mi wide) in the low stratum, 1,859 transects in the medium stratum, and 931 transects in the high stratum. Our sample consisted 75 transects (20, 35, and 20 transects in the low, medium, and high strata, respectively). Transects were well distributed across the northeastern sampling frame (Figure 1).

Transects were flown on 21-22 and 26-27 May 2015 for a total of 28.6 hours of flight time. The total cost for the flight time was $9,409. The air crew surveyed an average of 496 mi of transects per day (range: 306-659 mi/day). The total survey time was 15.5 hr, but this does not include transit or refueling times. Survey time per transect ranged from 5 to 19 min and it varied linearly as a function of transect length (R-squared = 0.985).

We observed 89 swans and 13 nests on 29 (38.7%) of the 75 0.25-mi wide transects. Most (88%) swan observations were single or paired birds; only 3 observations involved flocked swans (3, 3, and 5 swans). Counts on transects where we observed at least 1 swan ranged from 1 to 10 swans (median = 2, mean = 3.1). Swan counts per transect were not strongly correlated with transect length (Figure 2a) or amount of open-water habitat (Figure 2b). Likewise, the probability of observing at least one swan per transect was not correlated with open-water habitat (Z-test, P = 0.554). The proportion of transects with at least one swan observation was lowest in the low strata (15%) and highest in the medium strata (54%), whereas the proportion of transects in the high stratum with at least one swan observation was 35%. Not surprisingly then, GAP open-water habitat data was not a good stratification variable (i.e., the design effect was negligible, which means that precision of the estimate was not improved via stratification). We generally observed swans in small (less than 10 ac) open-water wetlands and on lakes that had small bays with wild rice (*Zizania palustris*), cattails (*Typha* sp.) and other emergent vegetation suitable for nesting. They were also observed in meandering rivers and streams that were bordered by emergent vegetation. We also observed swans in open-water ditches that were created in peatland areas in an attempt to drain and farm these areas; these ditches often do not show up on GAP or other geographic information system data layers.

The stratified ratio estimate for the Pilot Breeding Swan Survey based on 0.25-mi wide transects was 0.046 swans per mile (SE=0.009), which produced a population estimate of 4,420 swans (90% CI: 2,990- 5,840). The breakdown by social category was approximately 3,079 (70%) paired swans, 795 (18%) single swans, and 546 (12%) flocked birds. We observed an additional 77 swans and 16 nests when the transect width was extended to 0.5 mi. Count data from 0.5-mi wide transects produced a slightly smaller population estimate (4,140 swans) that was marginally more precise (CV = 18% vs. 20%).

Waterfowl Breeding Population Survey

We observed 235 swans on 53 (46.1%) of the 115 transects surveyed. Counts on transects where we observed at least 1 swan ranged from 1 to 19 swans (median = 3, mean = 4.4). Swan counts per transect were not strongly correlated with transect length (Figure 3).

The stratified ratio estimate for the Waterfowl Breeding Population Survey ranged from 0.001 to 0.102 swans per mile, which produced population estimates that ranged from 150 (2001) to 12,570 (2015) (Table 1). The estimated number of trumpeter swans based on this survey has increased steadily since 2000 (Figure 4). The results of the 2015 survey have been published online (http://files.dnr.state.mn.us/recreation/hunting/waterfowl/waterfowl_survey2015.pdf).

Five County Metro Area Count

Data were submitted from 5 May through 15 June 2015 with an additional observation submitted 3 August 2015 of a pair with cygnets. A total of 270 swans were counted in the five county metropolitan area (Figure 5) of which 100 were paired, 18 were single swans and 56 nests were found. Nine flocks were observed that ranged in size from 3 to 18 swans (median = 4, mean = 5.78). The count from this area should be considered a minimum number as a random sampling design was not employed for this count.

Statewide Trumpeter Swan Population Estimate

The statewide population estimate for 2015, excluding the metropolitan area was 16,990 swans (90% CI: 12,730- 21,250). Of the 190 transects surveyed in the 2 surveys 108 transects had no swans. For transects with swans, swans per mile of transect surveyed ranged from 0.033 to 2.395 (mean = 0.237, median = 0.133). Highest concentrations of swans were observed west of the metropolitan area and in the north-central part of the state (Figure 6). Including swans counted in the metropolitan area that did not overlap with the sampling frames for the two transect surveys, the total trumpeter swan population estimate for Minnesota was 17,021 swans. Percent change and annual growth have been reported in the North American Trumpeter Swans Survey report for the Interior Population. We provided similar calculations using Waterfowl Breeding Population Survey data for which we have breeding counts since 2000 (Table 2).

Winter counts have been used to monitor Minnesota's trumpeter swan population. However, this was the first year that a statewide breeding survey has been conducted, and thus comparisons to previous data are limited. Winter counts increased from 2000 to 2010, which is similar to the trend observed in the Waterfowl Breeding Population Survey (Figure 7). We also reviewed Christmas Bird Count data from the Mississippi Flyway since 1982. These data indicate the proportion of swans wintering in Minnesota has been relatively stable for the past five years, following a period of increasing wintering swan counts during the preceding 15 years. In the remainder of the flyway states, numbers of trumpeter swans by party hours have increased by 132% and proportion of swans wintering outside Minnesota has increased from ~18% in 2006 to ~57% in 2013 (Figure 8).

Discussion

The trumpeter swan population in Minnesota has increased steadily since the early 2000s. When reintroduction efforts began, the goal for Minnesota was 15 breeding pairs. This goal was later revised to 500 individuals by 2001 (Ad hoc drafting committee for the interior population of trumpeter swans 1998), but the population goals from the 1998 management plan for the interior

population of trumpeter swans were not reassessed or updated as reintroduction efforts continued. Many states met or exceeded the population goals from this plan during the 2000 North American Trumpeter Swan Survey and discontinued reintroduction efforts (Groves 2012). The Waterfowl Breeding Population Survey has documented swans annually during the breeding season since 2000. For the first 10 years, swans were increasing at a rate of about 500 swans per year. Around 2010, this rate increased to closer to 1,000 swans per year. However, estimates since 2011 have been quite variable, fluctuating by more than 3,000 swans annually. Much of the annual variability in population estimates is likely due to sampling variance (vs. true annual variation in population size), which can only be reduced by increasing sample sizes or making the design more efficient . But if one focuses on trends over time rather than individual population estimates, the Waterfowl Breeding Population Survey provides a reasonable estimate of population trends and status (Figure 4). We do not know how quickly the population has grown outside of the Waterfowl Breeding Population Survey sampling frame, but we suspect the number of swans in the northeastern part of the state has also been increasing.

We expect that the swan population will continue to grow, but we are less certain about the rate of growth. Although it was too early to count cygnets during 2015 surveys, past estimates indicated that cygnet production for the Interior Population was stable (Groves 2012). Swans were only detected on 43% of transects flown, even though habitat, based on our current understanding, appears to be available. It appears that the population has not yet saturated available habitat.

Counts conducted in Minnesota for the North American Trumpeter Swan Survey from 2000-2010 relied on a variety of labor-intensive techniques and were believed to represent the best counts of the population in Minnesota, although it is difficult to assess the accuracy of these counts. In 2000, data were collected May through January and used a combination of aerial and ground counts (Caithamer 2001). In 2005, an estimate was provided based on data collected spring through mid-winter as a formal count was not conducted (Moser 2006). The 2010 count was conducted in January and was believed to represent birds from Minnesota and southwestern Ontario (Groves 2012). This count took place during a narrow window and the organizers believed the conditions were ideal (e.g., deep snow forced birds into few open water locations) for documenting swans. The count comprised of an actual count of 5,470 trumpeter swans found in Minnesota and an estimated 600 swans that migrated from or through the state (personal communication M. Linck and L. Gillette). Data collected for these counts that included data collected in winter months closely track the data collected for the Waterfowl Breeding Population Survey; however, this survey only represents about 39% of the state. Furthermore, we may also have expected higher winter counts due to the addition of annual production, particularly with this population experiencing rapid growth. For these reasons, we believe that past winter counts should be considered minimum counts.

Bird movements in and out of Minnesota make it challenging to monitor this population in winter. While it was believed that winter counts conducted for the North American Trumpeter Swan Survey 2000-2010 represented a complete census of the population in Minnesota, trumpeter swan movements in and out of Minnesota have been documented (Ad hoc drafting committee for the interior population of trumpeter swans 1998). Although the Interior Population of swans is

growing in nearby states, we do not know where swans from Minnesota winter or how much they move during the winter (but see Ad hoc drafting committee for the interior population of trumpeter swans 1998). Christmas Bird Counts indicate that the proportion of swans wintering outside of Minnesota is increasing and because Minnesota has a very large proportion of the Interior Population (~62% in 2010; Groves 2012), it suggests that birds are migrating more in winter than once believed. An effort to mark birds in the future would improve our understanding of winter migration by trumpeter swans.

The relative precision of our survey estimates for swans in both the Waterfowl Breeding Population and Pilot Breeding Swan surveys were less than the MN DNR's normal target level of a 25% bound relative to the estimate. To improve the precision of these surveys we would need to: a) increase sample size (increase the number of transects surveyed and reduce the number of transects with zero swan observations), and/or b) improve the sampling design with auxiliary information (e.g., on spatial distribution of breeding swans and their habitat association). In 2015, stratifying by the amount of water using GAP data did not improve the precision our estimates (i.e., the design effect was negligible). We collected swan locations and habitat characteristics in the Pilot Breeding Swan Survey, which could potentially be used to refine this survey in the future.

The Pilot Breeding Swan Survey was the first transect survey flown for swans in northeastern Minnesota. While we generally believe visibility was good for swans during these surveys, the presence of tall trees in this heavily forested part of the state could have obscured some swans in some areas and may partially explain the lower estimated density of swans in the northeast compared south and central parts of the state where the habitat is more open. However, other statewide bird surveys (e.g., Minnesota Breeding Bird Atlas Project and Breeding Bird Survey) also indicate lower densities in this part of the state.

Given the data from this and other surveys, we believe that spring counts will provide more accurate estimates of population size and trends. We found that aerial transects are an efficient, cost effective way to collect data on these large and easily observed birds. Additionally, it was cost effective to supplement the annual Waterfowl Breeding Population Survey to count swans. We acknowledge that we are still missing portions of the state (far northwest and southeast) that may have breeding trumpeter swans, but given the best information we have on the distribution of the species and funding limitations, we believe we have a reasonable estimate of breeding trumpeter swans for Minnesota. We also acknowledge that our estimates have relatively wide confidence intervals. Given the current distribution of this population, improved precision would likely be more expensive to obtain. Going forward, having a clearer understanding of population goals and survey objectives will help us optimize the survey design.

Acknowledgements

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Tables

Table 1. Population estimates of trumpeter swans in Minnesota based on aerial transect surveys (2000-2015). Also included are standard errors (SE), 90% upper and lower confidence intervals (CI) and relative bound, which provides a measure of the confidence interval relative to the point estimate.

Survey[1]	Year	Estimate	SE	Lower CI	Upper CI	Relative Bound (%)
WBPS	2000	230	132	10	450	94%
WBPS	2001	150	103	2	320	113%
WBPS	2002	230	179	5	520	128%
WBPS	2003	2,030	1,038	320	3,740	84%
WBPS	2004	860	231	480	1,240	44%
WBPS	2005	2,400	1,147	510	4,290	79%
WBPS	2006	3,850	1,257	1,780	5,920	54%
WBPS	2007	2,070	635	1,030	3,110	51%
WBPS	2008	2,820	852	1,420	4,220	50%
WBPS	2009	5,330	2,223	1,670	8,990	69%
WBPS	2010	5,150	1,391	2,860	7,440	44%
WBPS	2011	10,620	4,880	2,590	18,650	76%
WBPS	2012	6,610	1,589	4,000	9,220	40%
WBPS	2013	11,450	2,517	7,310	15,590	36%
WBPS	2014	7,680	1,366	5,430	9,930	29%
WBPS	2015	12,570	2,439	8,560	16,580	32%
PBSS	2015	4,420	867	2,990	5,840	32%

[1] WBPS = Waterfowl Breeding Population Survey; PBSS = Pilot Breeding Swan Survey

Table 2. Percent change and average annual growth rates from Waterfowl Breeding Population Surveys (2000-2015) and the Interior Population (2000-2010; Moser 2006, Groves 2012).

	Waterfowl Breeding Population Survey		Interior Population	
Years	Total Percent Change	Annual Growth Rate	Total Percent Change	Annual Growth Rate
2000-2005	943%	33.0%	91%	13.0%
2005-2010	115%	14.6%	111%	16.1%
2010-2015	144%	16.8%	-	-

Figures

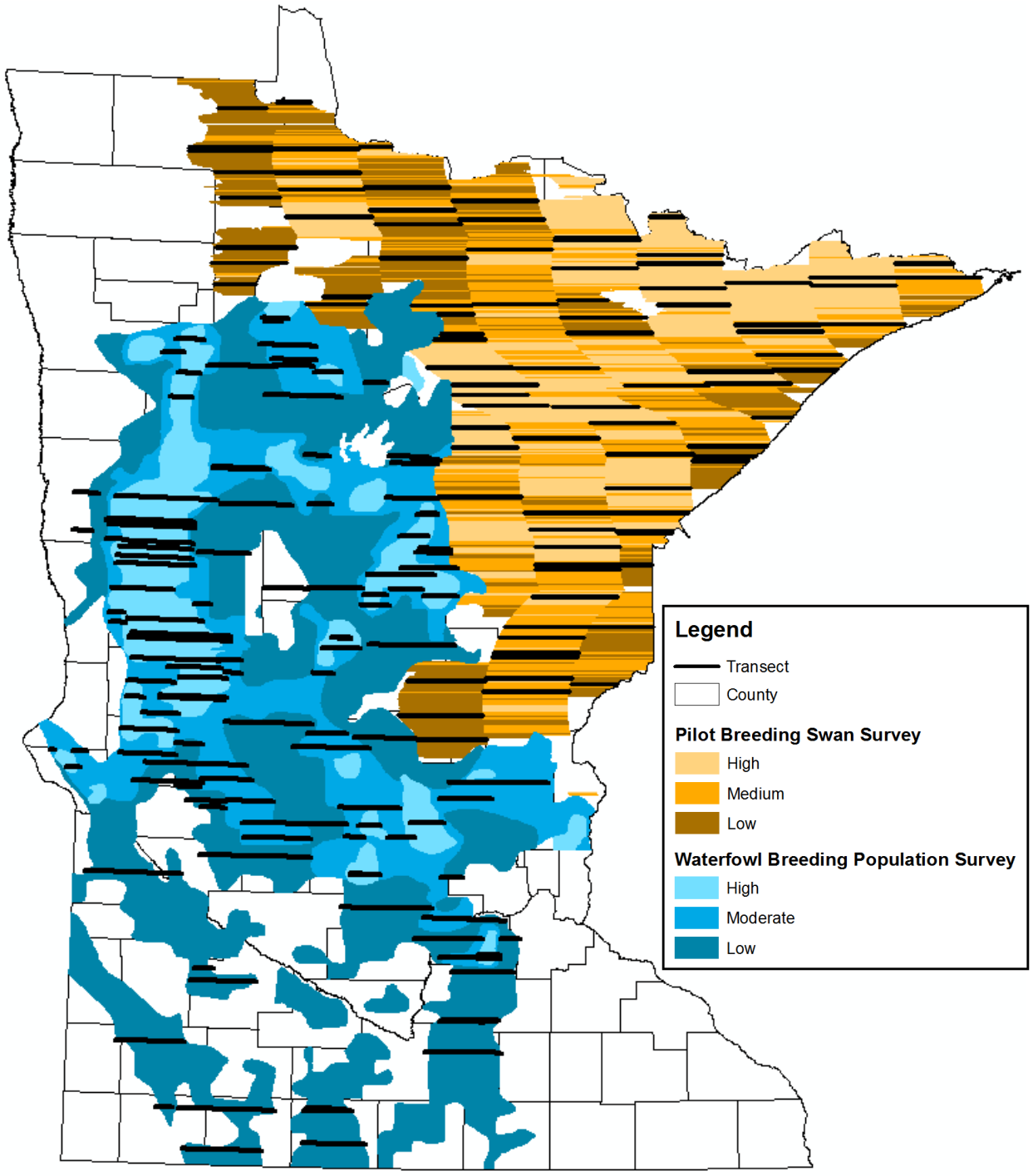
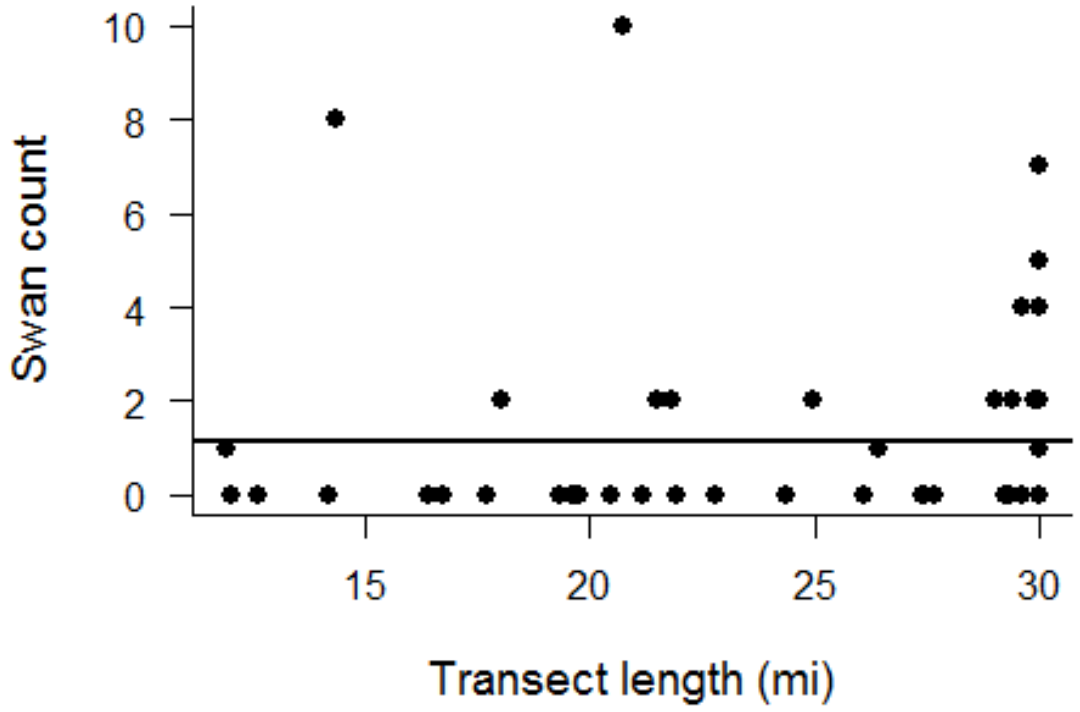


Figure 1. Map of the Waterfowl Breeding Population Survey and Pilot Breeding Swan Survey strata and associated transects.

a) -



b) -

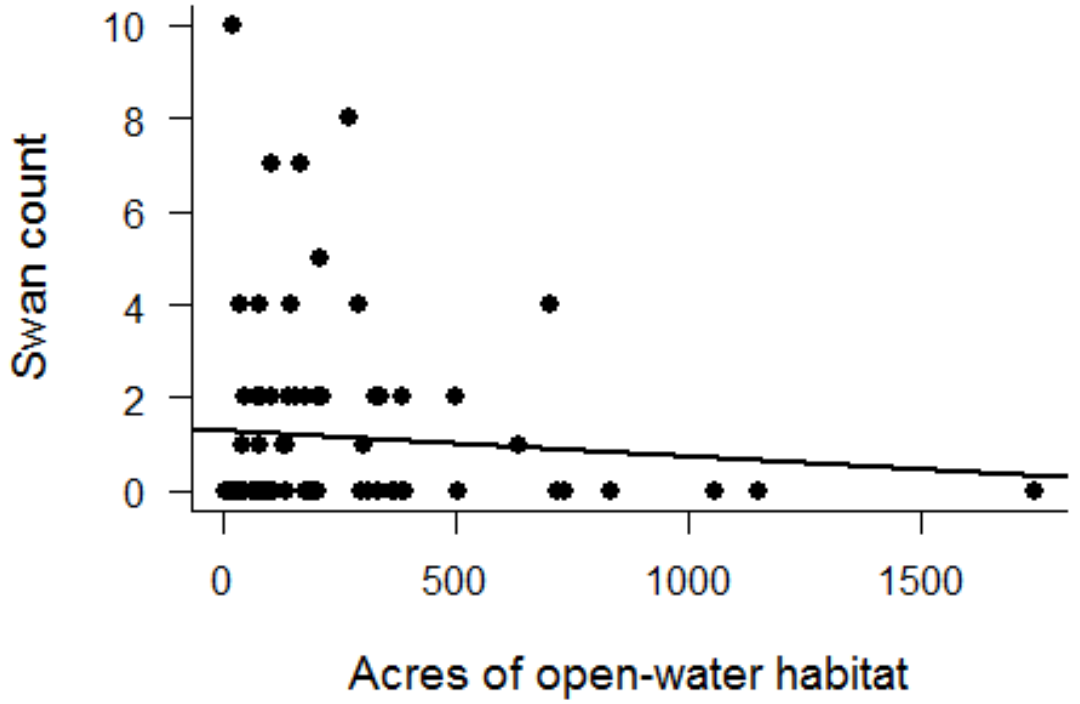


Figure 2. Scatterplots of swan counts versus a) transect length (mi) and b) acres of open-water habitat from the Pilot Breeding Swan Survey, May 2015.

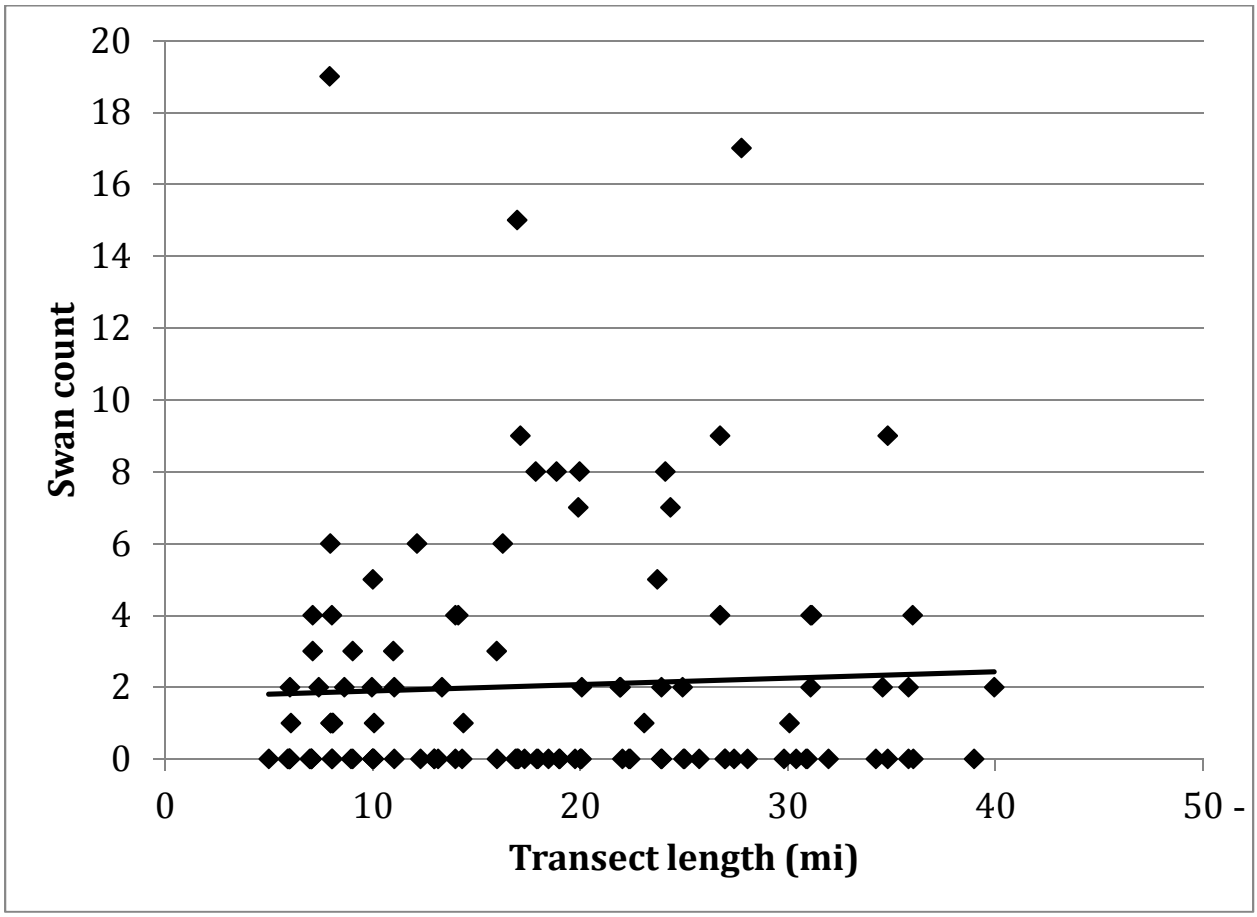


Figure 3. Scatterplot of swan counts versus transect length (mi) from the Waterfowl Breeding Population Survey, May 2015.

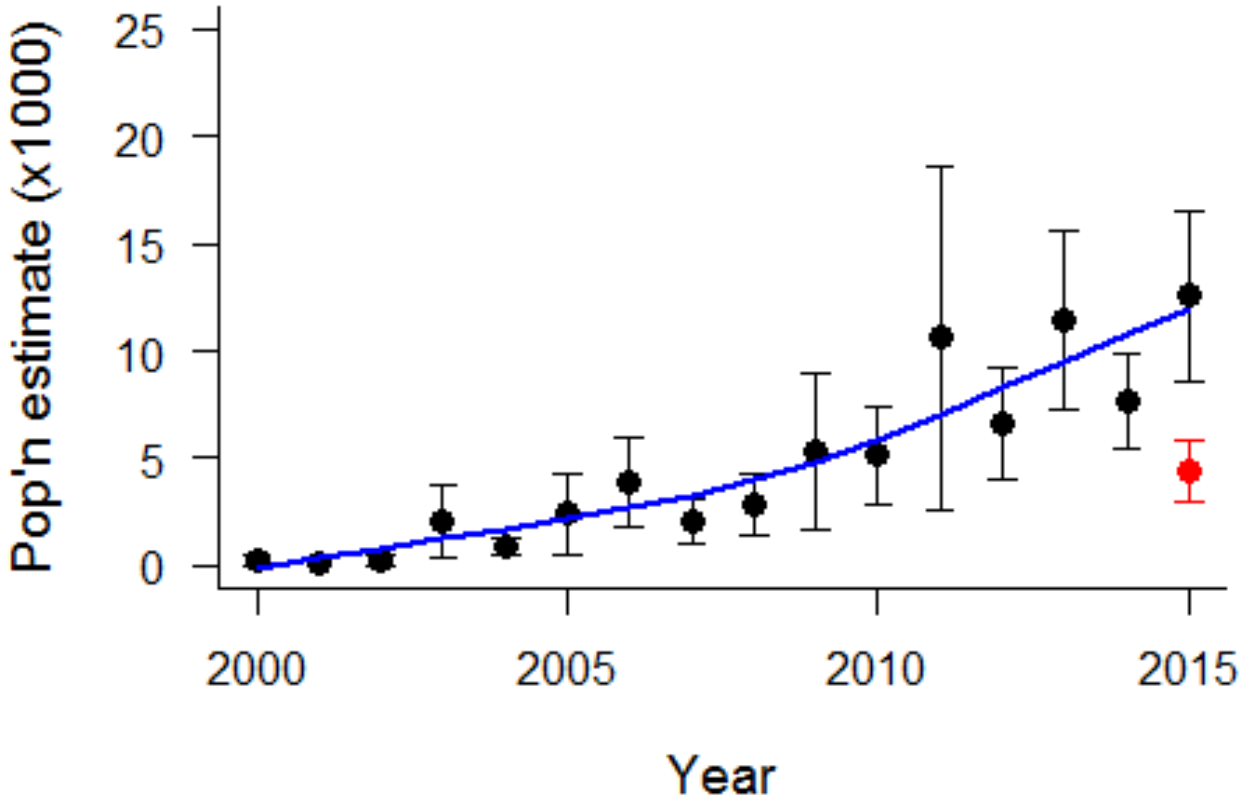


Figure 4. Population estimates of trumpeter swans with 90% confidence intervals in Minnesota based on aerial transect surveys. Waterfowl Breeding Population Survey (2000-2015, black) along with the smoothed trend (blue) and Pilot Breeding Swan (2015, red) are shown.

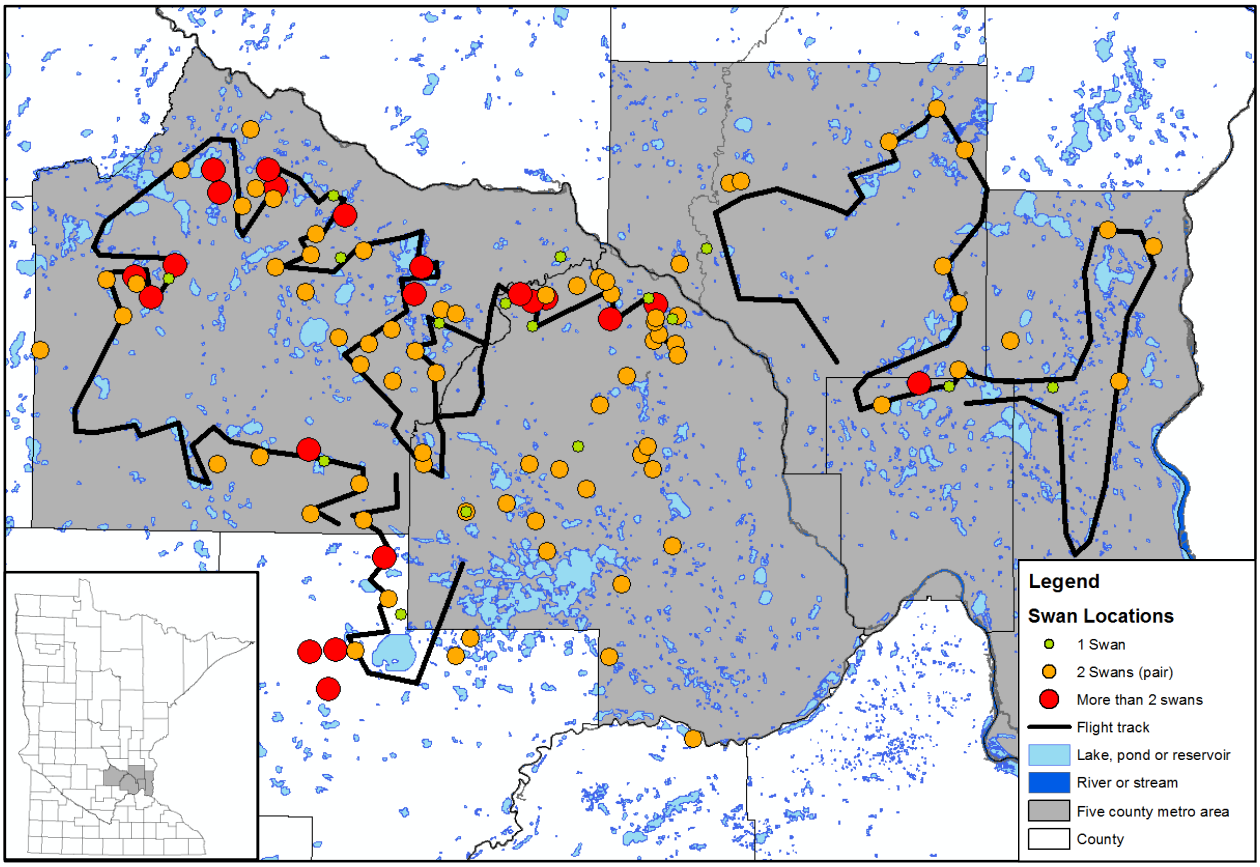


Figure 5. Five county metropolitan area with swan locations, lakes and rivers, and approximate flight tracks. Data were collected both from the air and from the ground, May through June 2015.

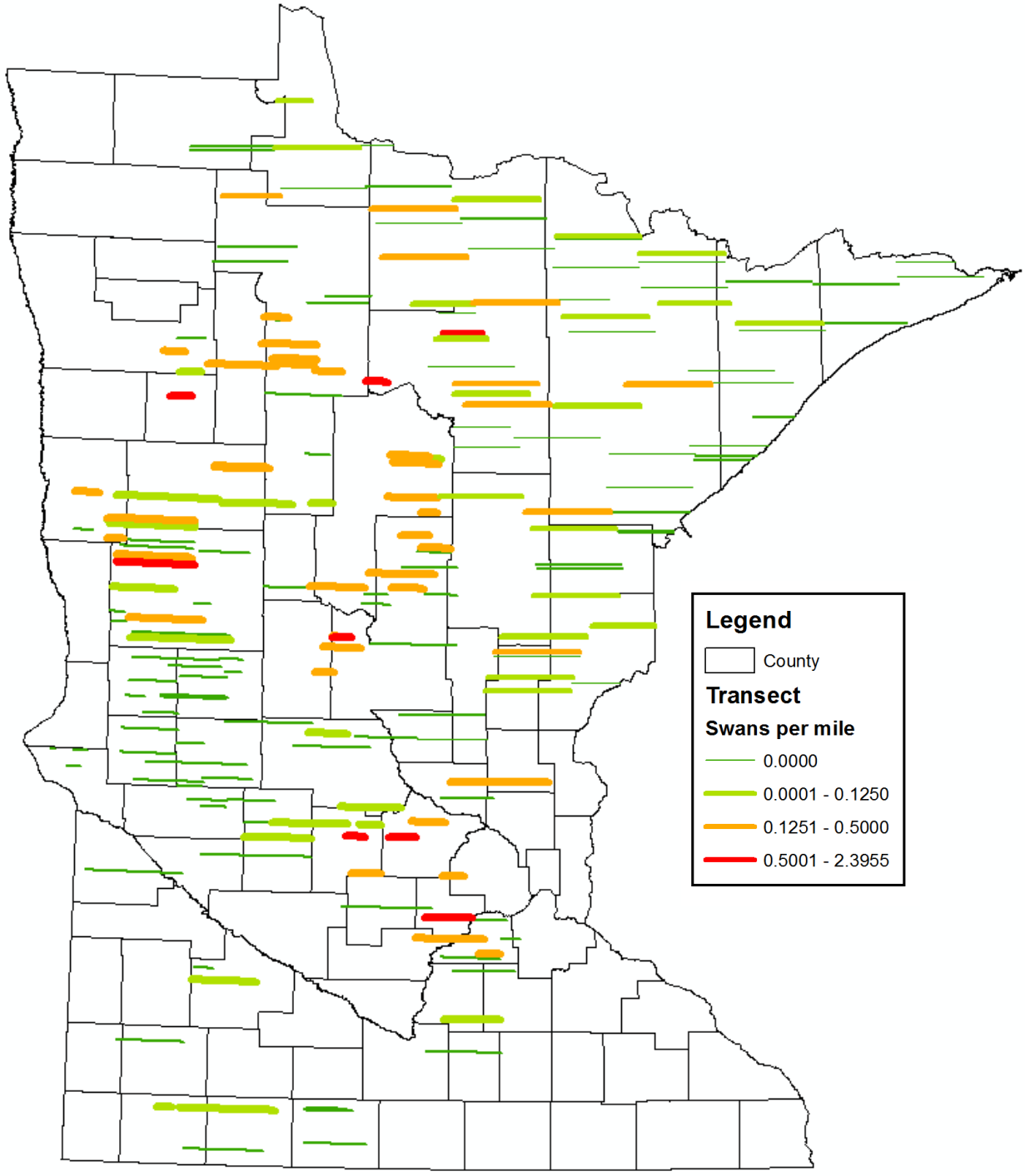


Figure 6. Number of swans per mile along surveyed transects from the Waterfowl Breeding Population and Pilot Breeding Swan surveys, May 2015.

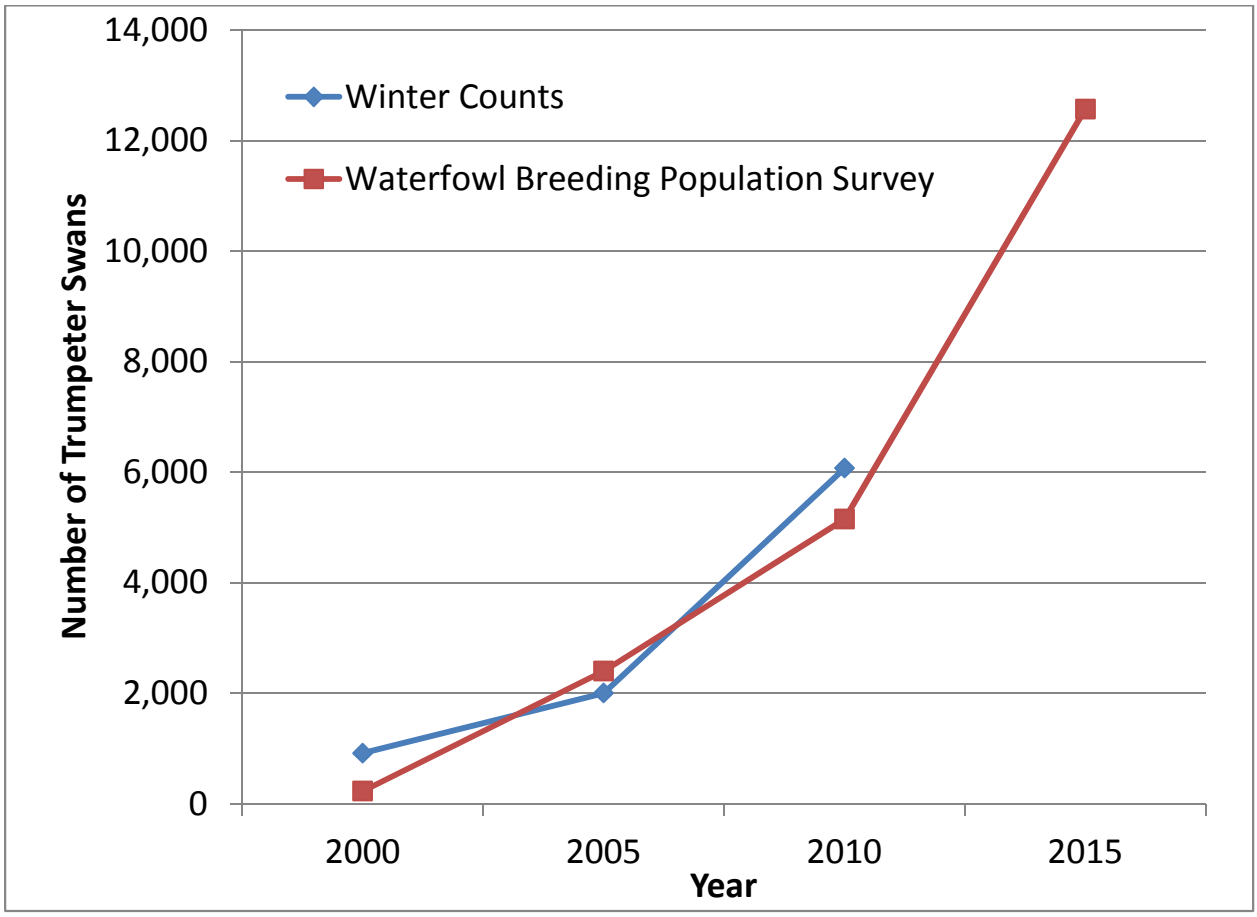


Figure 7. Winter counts conducted in Minnesota for the North American Trumpeter Swan Survey (2000-2010) and Waterfowl Breeding Population Survey (2000, 2005, 2010 and 2015).

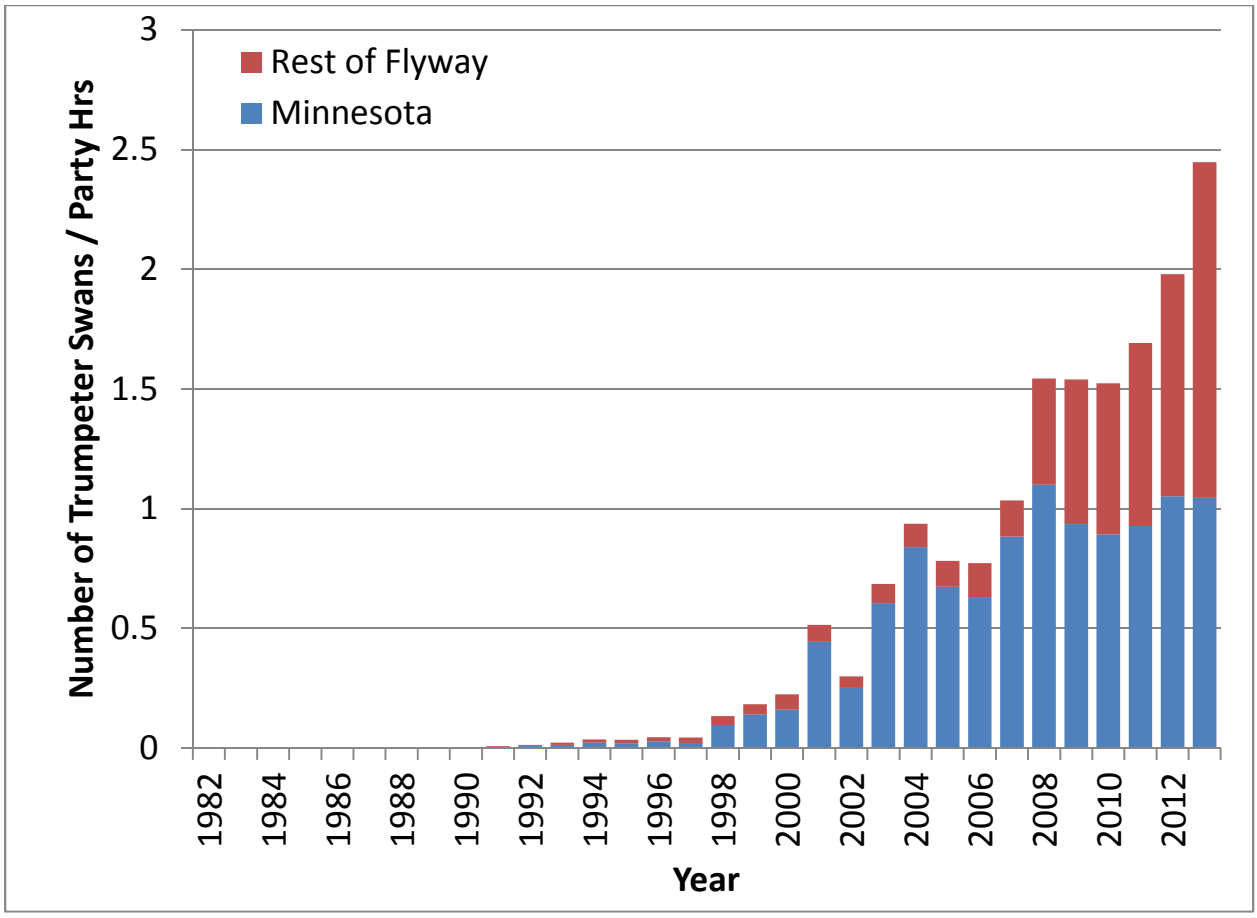


Figure 8. Christmas Bird Count data for trumpeter swans in Minnesota along with the remaining Mississippi Flyway states from 1982 to 2013 (National Audubon Society 2010).