

WISCONSIN DEPARTMENT OF NATURAL RESOURCES
Waterfowl Breeding Population Survey For Wisconsin, 1973–2023

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June 2023

Abstract

The 2023 Waterfowl Breeding Population Survey for Wisconsin was conducted from April 24–May 10 and followed methods of the North American Waterfowl Breeding Population and Habitat Survey. The information from this survey is used as part of the overall survey of breeding waterfowl in North America as well as in making state-level waterfowl management decisions. This survey has been conducted annually since 1973 (except for 2020), and data on Wisconsin waterfowl breeding populations and wetland counts are best interpreted as trends over several years rather than as year-to-year fluctuations.

Total non-linear basins were down 3.5% from 2022 in the Southeast Central (SEC) region and up 108.7% from the long-term, 50-year mean. In the Northern High Density (NHI) region, total non-linear basins were up 8.8% from 2022 and up 124.1% from the long-term mean. Non-linear basins were down 6.6% from 2022 in the Northern Low Density (NLO) region and up 203.1% from the long-term mean. Non-linear basins were up 38.4% from 2022 in the Southwest Driftless (SWD) region and up 83.9% compared to this region's long-term (26-year) mean. Total linear basins were down 6.2% from 2022 in the SEC region and up 48.7% from the long-term mean. In the NHI region, linear basins were down 23.3% from 2022 and up 69.1% from the long-term mean. NLO region linear basins were down 8.6% from 2022 and up 90.2% from the long-term mean. Linear basins were up 45.0% from 2022 in the SWD region and up 68.9% from the long-term mean.

The 2023 total breeding duck modeled population estimate of 545,065 was 3.5% lower than the 2022 modeled estimate of 564,738, and was 23.4% higher than the long-term mean. The mallard modeled breeding population estimate of 175,895 was 0.6% lower than the 2022 estimate of 176,977 and was 1.5% lower than the long-term mean. The blue-winged teal modeled breeding population estimate of 96,271 was 6.2% higher compared to the 2022 estimate of 90,638, but remains 8.5% lower than the long-term mean. At

102,381 the 2023 population estimate for wood ducks was 29.0% lower than the 2022 estimate of 144,254 and 19.9% higher than the long-term mean. The modeled Canada goose population estimate of 169,447 was 1.3% lower compared to the 2022 estimate of 171,667, and 58.4% higher than the long-term mean. The population estimate of “other ducks” was 153,295, which was 1.8% lower than the 2022 estimate of 156,095 and was 134.7% higher than the long-term mean.

Introduction

Decisions regarding hunting season structure and harvest limits in waterfowl management are based in part upon spring breeding pair surveys. The U.S. Fish and Wildlife Service's (USFWS) [Waterfowl Breeding Population and Habitat Survey \(BPOP\)](#) has been conducted for 69 years across the traditional survey area of the north-central United States, Canada and Alaska. The Wisconsin Waterfowl Breeding Population Survey—which is modeled after the BPOP—has been conducted since 1973 and provides a long-term record of waterfowl breeding trends and wetland counts in Wisconsin. These data are used at the national- and state-level for monitoring waterfowl populations and making management decisions. Wisconsin's breeding waterfowl survey data are included in the [Waterfowl Population Status report](#) published annually by the USFWS on continental waterfowl populations. In addition, mallard data from Wisconsin, Minnesota, and Michigan are combined with data from the traditional survey area as a basis for the USFWS's [Adaptive Harvest Management report](#) that is used to establish federal waterfowl season frameworks. At the state-level, waterfowl breeding survey data are used to inform annual hunting season regulations, identify long-term changes in population trends, and evaluate the impacts of habitat changes and management. This report provides a summary and analysis of the 2023 survey data in support of these efforts.

Methods

Study area and survey timing

The Wisconsin Waterfowl Breeding Population Survey employs a stratified sampling scheme modeled after the BPOP survey (Platte 1987) but modified for local conditions (March et al. 1973). The state is divided into four strata based on regional waterfowl densities and habitat attributes: the Southeast Central region (SEC), Northern High Density region (NHI), Northern Low Density region (NLO), and Southwest Driftless region (SWD; Figure 1). Fifty-five east-west oriented transects, each 30 mi in length and 1/4 mi-wide, were randomly selected in 1973 within the SEC ($n = 29$), NHI ($n = 13$), and NLO ($n = 13$) regions; transects in the SWD region ($n = 11$) were not added until 1997 due to low wetland density. Surveys have been conducted every year since 1973, except in 2020 due to the COVID-19 pandemic.

Transects are typically surveyed from May 1–20 to obtain accurate estimates of *local* breeding pairs. However, the start date may be adjusted to accommodate inter-annual variation in the timing of spring (i.e., to exclude migratory individuals and minimize the effects of leaf-out on observer visibility). To account for latitudinal differences in leaf-out and waterfowl breeding phenology, surveys are generally initiated in southern Wisconsin and northern transects are the last to be completed.

Data collection

Two observers—each experienced in waterfowl identification and waterfowl census procedures—performed the aerial surveys. To minimize problems with observer bias, the same aerial observers are used for a minimum five-year period. In addition, surveys do not take place when winds exceed 25 mph or if other adverse weather conditions exist (e.g., snow, rain, fog, and smoke). Fixed-wing aerial surveys were conducted from a Cessna 182 aircraft, flying at 90–100 mph and 100–150 ft above ground level. During each transect flight, an observer recorded all observations of ducks, geese, coots, cranes, and swans within a 1/8-mile strip from either side of the aircraft, while the observer on the north side of the plane recorded the number and type of unoccupied wetland basins containing surface water. All wetlands within the 1/4-mile transect width on which breeding waterfowl are observed (i.e., occupied wetlands) are also recorded by the observer counting waterfowl.

Given the challenges of detecting and counting waterfowl from the air, 27 segments of selected aerial transects are censused by ground crews to obtain a ‘complete’ count of all waterfowl present and calculate visibility (air-to-ground) correction factors (VCFs). Ground crews (2–4 individuals) cover every wetland basin within a transect segment on foot or by boat on the same day or within 2 days after the air count. Ground observers record waterfowl observations according to the same instructions for the aerial survey.

Data preparation

The Waterfowl Breeding Population Survey focuses on four priority waterfowl species: mallards (*Anas platyrhynchos*), blue-winged teal (*A. discors*), wood ducks (*Aix sponsa*) and Canada geese (*Branta canadensis*). All other duck species that are likely breeders in Wisconsin are pooled into a category of “other ducks” (“total ducks” combines these four priority species and “other ducks”). By 2004, wood duck populations had increased to a level where we were able to estimate them as a separate group rather than as part of “other ducks.” Lesser scaup (*Aythya affinis*) and bufflehead (*Bucephala albeola*) are not included in population estimates because they rarely breed in Wisconsin and when counted are assumed to be in migration to more northern breeding areas. We also tallied counts for several other species of interest: American coots (*Fulica americana*), whooping cranes (*Grus americana*), sandhill cranes (*Antigone canadensis*), and trumpeter swans (*Cygnus buccinator*).

We note that this survey was not originally designed for surveying Wisconsin’s resident Canada goose population due to their earlier breeding phenology. However, aerial counts of geese increased steadily from the mid-1980s through the early 2000s, making survey estimates useful indices of population trends. Human-goose conflicts resulting from a growing goose population increase the importance of tracking the population status of breeding geese in Wisconsin, and have been included in this report since 1986.

Prior to analysis, we calculated the total numbers of “indicated” birds for each transect based on the observation type (i.e., pairs, lone drakes, flocked drakes [males in groups

of 2–4], and groups [≥ 5 drakes or mixed flocks that cannot be separated into pairs or sexes]) and each species' breeding biology. In general, lone drakes, flocked drakes, and pairs are adjusted by a multiplier of two, while groups are not adjusted.

Statistical analysis

Visibility correction factors

The VCF (also referred to as R ; see below) is the ratio of individuals counted by ground crews to the number of individuals counted by aerial crews from the same set of transect segments. VCFs are used as a multiplier to the aerial survey counts and yield statewide, corrected abundance estimates. VCFs were calculated independently for all priority waterfowl species and “other ducks” by pooling data from all 27 air/ground transect segments. To quantify VCF precision, we calculated the coefficient of variation (CV), which provides a standardized measure of dispersion. We iteratively added prior years of survey data until a CV value ≤ 0.20 (and a robust VCF) was achieved.

Population estimates

To calculate species-specific and visibility-corrected abundance estimates in each region, we used the traditional formula developed by Smith (1995):

$$N = B \times A \times R \quad (1)$$

where B is the bird density per mi^2 , A is the area of the survey region, and R is the visibility correction factor. We note that this procedure was only conducted for the four priority waterfowl species and “other ducks” (VCF-corrected estimates were summed across these groups to estimate “total duck” abundance).

Because these abundance estimates are imperfect counts (i.e., some combination of true population size and detection error), we elected to model annual trends using a Bayesian state-space modeling approach (Kéry and Schaub 2012). State-space models are hierarchical models that simultaneously account for process error (true population size change) and measurement error (survey biases), and are increasingly used to model ecological time series (Auger-Méthé et al. 2021). State-space models offer at least two important advantages. First, modeled survey estimates smooth out drastic annual changes in population estimates that are biologically unrealistic (e.g., mallard abundance changing from roughly 250,000 in 1999, 450,000 in 2000, and then 180,000 in 2001). Second, a Bayesian state-space model allows for prediction, even when counts are unavailable (e.g., when surveys were canceled in 2020 due to the COVID-19 pandemic). Therefore, in the following waterfowl summaries we reference abundance and percent changes in state-space estimates rather than the raw population estimates. However, for comparison and continuity with previous reports, we provide both estimate types in the associated tables and figures (state-space modeling was first implemented for the 2021 report). We report the mean population estimate and 95% credible

interval (CI), which can be interpreted as saying ‘*the true population size has a 95% probability of falling within this range, given the observed data.*’

Implementation

Data processing, analysis, and visualization were implemented using R software (RStudio Team 2020). We compiled the survey report in R Markdown (Allaire et al. 2022).

Results

Survey timing

We initiated the 2023 Waterfowl Breeding Population Survey on April 24. As in the past, the survey was initiated in the southern part of Wisconsin, progressing northward to account for the differences in phenology from south to north. The timing of the breeding waterfowl survey is always a challenge because variables such as weather, waterfowl phenology, and tree leaf-out all impact the timing, visibility and accuracy of the survey. Weather conditions were wetter and cooler than average during the survey statewide. Conditions in the south were slightly drier than the north but similar to last year we had above average wet conditions and late ice out in much of the north with some lakes retaining ice during the survey time period in late April/early May.

Aerial surveys were completed in 10 days from April 24 to May 10. The ground survey was completed in 7 days from April 26 to May 6. Paired aerial and ground surveys occurred within 2 days of each other, except for one transect segment where aerial/ground surveys occurred within 3 days.

Wetland counts

In the SEC region, total non-linear basins were down 3.5% from 2022 and were up 108.7% from the long-term (50-year) mean. Linear basins in the SEC region were down 6.2% from 2022 and up 48.7% from the long-term mean (Table 1). In the NHI region, total non-linear basins were up 8.8% from 2022 and up 124.1% from the long-term mean. Linear basins in the NHI region were down 23.3% from 2022 and up 69.1% from the long-term mean (Table 2). In the NLO region, total non-linear basins were down 6.6% from 2022 and up 203.1% from the long-term mean. Linear basins in the NLO region were down 8.6% from 2022 and up 90.2% from the long-term mean (Table 3). In the SWD region, total non-linear basins were up 38.4% from 2022 and up 83.9% from this region’s long-term, 26-year mean. Linear basins in the SWD region were up 45.0% from 2022 and up 68.9% from the long-term mean (Table 4). Long-term wetland counts for each survey region are shown in Figure 2.

Waterfowl population estimates

2023 VCF and population estimate summary statistics for mallards, blue-winged teal, wood ducks, “other ducks”, and Canada geese are provided in Table 5. Unless otherwise noted, population estimates provided below are derived from state-space models.

Mallards

The 2023 modeled mallard population estimate was **175,895 (95% credible interval [CI] = 131,956–227,236 individuals)**. This estimate is 0.6% lower compared to the previous year’s modeled estimate and 1.5% lower than the long-term, 50-year mean (Table 6; Figure 3). As in previous years, the SEC still represented the largest portion of the breeding mallard population (41%) and was similar to that of 2022.

Blue-winged teal

The 2023 modeled population estimate for blue-winged teal was **96,271 (95% CI = 58,301–151,996 individuals)**. This estimate was 6.2% higher compared to the previous year’s modeled estimate but remains 8.5% lower than the long-term mean (Table 6; Figure 4).

Wood ducks

The 2023 population estimate for wood ducks was **102,381 (95% CI = 64,730–173,810 individuals)**. This estimate was 29.0% lower compared to the previous year and was 19.9% higher than the long-term mean (Table 6; Figure 5).

Other ducks

The 2023 modeled population estimate for “other ducks” was **153,295 (95% CI = 76,590–277,462 individuals)**. This estimate was 1.8% lower compared to the previous year and was 134.7% higher than the long-term mean (Table 6; Figure 6). Species considered as “other ducks” and their percent composition in the 2023 uncorrected aerial count were: American black duck (*A. rubripes*; 1%), northern pintail (*A. acuta*; 0%), gadwall (*Mareca strepera*; 2%), American wigeon (*M. americana*; 3%), northern shoveler (*Spatula clypeata*; 1%), green-winged teal (*A. carolinensis*; 2%), canvasback (*A. valisineria*; 4%), redhead (*A. americana*; 1%), ring-necked duck (*A. collaris*; 39%), common goldeneye (*B. clangula*; 1%), hooded merganser (*Lophodytes cucullatus*; 3%), common merganser (*Mergus merganser*; 36%), red-breasted merganser (*M. serrator*; 0%), and ruddy duck (*Oxyura jamaicensis*; 8%).

Total ducks

The 2023 population estimate for all breeding ducks was **545,065 (95% CI = 411,225–708,254 individuals)**. This estimate was 3.5% lower compared to the previous year and is 23.4% higher than the long-term mean (Table 6; Figure 7).

Canada geese

Based on the most recent harvest derivations, the proportion of the Wisconsin Canada goose harvest that consists of temperate breeding (formerly 'giant') Canada geese is about 60%, with most of those birds representing Canada geese that breed in Wisconsin (Dooley 2017). This proportion indicates the continued importance of in-state breeding Canada geese in our overall fall harvest. The 2023 population estimate for Canada geese was **169,447 (95% CI = 124,907–229,885 individuals)**. This estimate was 1.3% lower than the previous year's modeled estimate and was 58.4% higher than the long-term, 37-year mean (Table 6; Figure 8). The long-term trend in goose numbers suggests a continued, gradual increase in their population.

American coots, cranes, and trumpeter swans

In 2023, observers counted a total of 242 coots, 0 whooping cranes, and 112 sandhill cranes (Figure 9). Excluding groups of five or more, 102 trumpeter swans were recorded and the 2023 population estimate for swans (accounting for bird density and survey region area, but lacking VCF-correction) was **13,643 (95% CI = 6,682–25,297 individuals)**; Table 7; Figure 10).

Acknowledgments

We thank Larry Waskow for piloting the aircraft, and Patrice Evers and Steve Burns for serving as additional aerial observers. For ground surveys, we thank Tonya Aldred, Kaleb Bolder, Eric Borchert, Ben Breaker, Michelle Carlisle, Nancy Christel, Jaqi Christopher, James Christopoulos, Jason Cotter, Steve Easterly, Colton Erickson, Jenna Fastner, Alaina Gerrits, Dan Goltz, Tally Hamilton, Emma Hansen, Jed Hopp, Derek Johnson, Alissa Kakatsch, Tanner Klein, Carissa Knab, Eric Kroening, Missy-Sparrow Lien, Doug Mittelstaedt, Chad Mogen, Allicyn Nelson, Aaron Seitz, Terry Shaurette, Brandon Stefanski, Brendan Woodall, Bryan Woodbury, Mark Worth, Cassandra Young, and Zack Zuleger.

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Tables

Table 1: Type and number of wetlands per square mile observed during the last 10-year period (2013–2023; surveys were not conducted in 2020 due to the COVID-19 pandemic), SEC region.

Year	Wetland type							
	I, II, VI	III	IV, V	VII, VIII	Non-linear	Stream	Ditch	Linear
2013	2.5	1.0	3.2	0.6	7.3	1.8	2.5	4.2
2014	3.0	1.0	3.1	1.2	8.3	1.7	2.8	4.5
2015	1.3	0.8	2.7	0.7	5.6	1.8	2.4	4.2
2016	2.1	0.9	3.0	1.0	6.8	1.5	2.2	3.7
2017	9.2	1.1	3.6	1.9	15.8	1.9	3.2	5.1
2018	6.5	0.8	3.3	1.6	12.2	1.9	3.1	4.9
2019	7.7	2.1	4.7	2.3	16.9	1.5	3.8	5.4
2021	2.9	0.9	5.0	1.8	10.6	2.6	2.8	5.4
2022	9.3	2.3	5.1	3.1	19.9	2.7	4.2	6.8
2023	9.0	2.6	5.7	1.8	19.2	2.5	3.9	6.4
% Change from previous year	-4.0%	16.0%	11.3%	-41.1%	-3.5%	-5.7%	-6.6%	-6.2%
Long-term mean (1973–2022)	4.0	1.0	3.1	1.2	9.2	1.8	2.5	4.3
% Change from long-term mean	124.4%	174.7%	87.7%	55.4%	108.7%	41.8%	53.6%	48.7%
10-year mean (2013–2023)	5.4	1.4	3.9	1.6	12.2	2.0	3.1	5.1

Notes: Wetland classification system from March et al. (1973). I, II, VI = temporary, wet meadow, and shrub swamps; III = seasonal wetlands, IV, V = semi-permanent and permanent/open water wetlands; VII, VIII = wooded swamp and bog wetlands. Non-linear wetlands include type I–VIII wetlands, and linear wetlands include streams and ditches.

Table 2: Type and number of wetlands per square mile observed during the last 10-year period (2013–2023; surveys were not conducted in 2020 due to the COVID-19 pandemic), NHI region.

Year	Wetland type							
	I, II, VI	III	IV, V	VII, VIII	Non-linear	Stream	Ditch	Linear
2013	2.9	2.1	4.0	0.6	9.6	2.8	0.6	3.3
2014	6.4	1.8	5.7	2.4	16.3	2.9	0.6	3.5
2015	2.6	1.3	3.5	1.7	9.1	2.1	0.6	2.7
2016	2.4	1.2	3.4	1.9	8.9	1.9	0.6	2.5
2017	3.5	1.8	3.6	3.4	12.3	1.8	0.9	2.7
2018	1.5	1.2	4.5	1.5	8.6	2.4	0.5	2.9
2019	2.4	2.6	5.5	1.7	12.2	2.8	0.4	3.2
2021	1.4	1.1	5.8	5.3	13.5	3.2	0.3	3.6
2022	3.2	3.3	5.1	11.4	23.0	4.8	1.4	6.2
2023	5.5	2.5	11.5	5.6	25.1	3.6	1.1	4.7
% Change from previous year	71.1%	-25.2%	124.2%	-51.0%	8.8%	-25.4%	-15.8%	-23.3%
Long-term mean (1973–2022)	3.4	1.4	4.1	2.3	11.2	2.3	0.5	2.8
% Change from long-term mean	63.2%	78.4%	183.1%	136.9%	124.1%	53.1%	150.6%	69.1%
10-year mean (2013–2023)	3.2	1.9	5.3	3.5	13.9	2.8	0.7	3.5

Notes: Wetland classification system from March et al. (1973). I, II, VI = temporary, wet meadow, and shrub swamps; III = seasonal wetlands, IV, V = semi-permanent and permanent/open water wetlands; VII, VIII = wooded swamp and bog wetlands. Non-linear wetlands include type I–VIII wetlands, and linear wetlands include streams and ditches.

Table 3: Type and number of wetlands per square mile observed during the last 10-year period (2013–2023; surveys were not conducted in 2020 due to the COVID-19 pandemic), NLO region.

Year	Wetland type							
	I, II, VI	III	IV, V	VII, VIII	Non-linear	Stream	Ditch	Linear
2013	3.4	1.0	2.5	0.7	7.6	3.8	0.8	4.6
2014	8.8	0.5	2.0	2.7	14.1	4.6	1.7	6.2
2015	1.7	0.6	1.8	1.1	5.2	3.0	0.9	3.9
2016	1.8	0.8	2.1	1.2	5.9	2.8	0.8	3.6
2017	4.7	0.8	2.1	2.9	10.6	2.9	1.4	4.2
2018	2.8	0.8	2.9	2.6	9.1	5.0	1.3	6.2
2019	5.6	1.7	3.5	1.9	12.6	4.0	1.2	5.2
2021	3.0	1.2	3.8	4.7	12.7	4.9	1.3	6.3
2022	13.7	1.5	3.4	13.1	31.7	5.6	3.7	9.2
2023	13.7	2.1	8.9	4.9	29.6	5.3	3.2	8.4
% Change from previous year	-0.4%	43.2%	161.4%	-62.5%	-6.6%	-5.3%	-13.5%	-8.6%
Long-term mean (1973–2022)	4.3	0.8	2.3	2.3	9.8	3.6	0.9	4.4
% Change from long-term mean	217.1%	159.5%	287.7%	109.5%	203.1%	48.1%	263.2%	90.2%
10-year mean (2013–2023)	5.9	1.1	3.3	3.6	13.9	4.2	1.6	5.8

Notes: Wetland classification system from March et al. (1973). I, II, VI = temporary, wet meadow, and shrub swamps; III = seasonal wetlands, IV, V = semi-permanent and permanent/open water wetlands; VII, VIII = wooded swamp and bog wetlands. Non-linear wetlands include type I–VIII wetlands, and linear wetlands include streams and ditches.

Table 4: Type and number of wetlands per square mile observed during the last 10-year period (2013–2023; surveys were not conducted in 2020 due to the COVID-19 pandemic), SWD region.

Year	Wetland type							
	I, II, VI	III	IV, V	VII, VIII	Non-linear	Stream	Ditch	Linear
2013	1.4	0.5	1.3	0.4	3.6	3.6	0.8	4.4
2014	2.3	0.6	1.7	0.5	5.1	3.4	1.3	4.7
2015	0.7	0.2	1.3	0.3	2.6	2.8	0.7	3.5
2016	0.3	0.3	1.1	0.3	2.0	2.5	0.8	3.3
2017	3.4	0.5	1.9	0.7	6.5	3.6	1.2	4.8
2018	1.8	0.3	1.5	0.3	3.9	3.2	0.8	4.1
2019	3.2	1.0	1.8	0.7	6.7	3.6	1.4	5.0
2021	0.8	0.4	2.0	0.2	3.4	4.8	0.6	5.4
2022	2.0	0.6	1.2	0.9	4.7	3.4	1.1	4.5
2023	2.8	0.5	2.3	0.8	6.6	5.0	1.6	6.6
% Change from previous year	40.1%	-4.3%	90.1%	-7.9%	38.4%	45.9%	42.4%	45.0%
Long-term mean (1973–2022)	1.4	0.3	1.5	0.3	3.6	3.2	0.7	3.9
% Change from long-term mean	104.4%	60.5%	50.7%	189.3%	83.9%	55.3%	132.3%	68.9%
10-year mean (2013–2023)	1.9	0.5	1.6	0.5	4.5	3.6	1.0	4.6

Notes: Wetland classification system from March et al. (1973). I, II, VI = temporary, wet meadow, and shrub swamps; III = seasonal wetlands, IV, V = semi-permanent and permanent/open water wetlands; VII, VIII = wooded swamp and bog wetlands. Non-linear wetlands include type I–VIII wetlands, and linear wetlands include streams and ditches.

Table 5: Statewide and stratum-specific population estimates for the 2023 Waterfowl Breeding Population Survey population estimates.

Stratum [*]	Area of stratum (mi ²)	Bird density seen from the air (birds/mi ²)	Aerial visibility correction factor [†]	Survey estimate	Standard error
Mallard					
SEC	17,949	3.595	1.050	67,754	12,090
NHI	9,431	3.897	1.050	38,591	7,797
NLO	15,979	2.810	1.050	47,146	15,521
SWD	12,311	1.018	1.050	13,160	4,095
Statewide total				166,651	21,555
Blue-winged teal					
SEC	17,949	0.520	4.904	45,732	15,593
NHI	9,431	1.323	4.904	61,193	20,149
NLO	15,979	0.092	4.904	7,233	4,480
SWD	12,311	0.048	4.904	2,927	2,011
Statewide total				117,085	25,947
Wood duck					
SEC	17,949	0.749	3.015	40,562	9,259
NHI	9,431	0.205	3.015	5,834	3,244
NLO	15,979	0.226	3.015	10,872	4,479
SWD	12,311	0.436	3.015	16,199	6,999
Statewide total				73,467	12,857
Other duck species^a					
SEC	17,949	0.782	4.168	58,467	15,851
NHI	9,431	1.610	4.168	63,290	22,055
NLO	15,979	0.338	4.168	22,539	9,555
SWD	12,311	0.061	4.168	3,110	3,110
Statewide total				147,406	28,959
Canada goose					
SEC	17,949	2.915	1.590	83,206	12,747
NHI	9,431	1.497	1.590	22,459	8,067
NLO	15,979	1.056	1.590	26,845	8,526
SWD	12,311	1.164	1.590	22,782	9,892
Statewide total				155,292	19,953

^{*} SEC = Southeast Central, NHI = Northern High, NLO = Northern Low, SWD = Southwest Driftless Strata.

[†] Aerial Visibility Correction Factor = ratio of number of species-specific individuals seen from the ground divided by the number seen from the air on air-ground segments, pooled across strata. To achieve a desirable coefficient of variation (CV) value in the aerial visibility correction factor, previous years of air-ground data were iteratively added until CV was <20%. In 2023, aerial visibility correction factors for mallards, blue-winged teal, wood ducks, Canada geese, and "other ducks" were derived using 1, 14, 5, 1, and 12 years of air-ground data, respectively.

^a Lesser scaup, bufflehead, and all non-duck/goose waterbirds are excluded from analysis. Common duck species categorized as "other ducks" include: ring-necked duck, common goldeneye, northern shoveler, hooded merganser, common merganser, gadwall, green-winged teal, and canvasback.

Table 6: Statewide breeding waterfowl population survey estimates and corresponding Bayesian state-space modeled estimates (highlighted in bold) in Wisconsin, 1973–2023. Note that surveys were not conducted in 2020 due to the COVID-19 pandemic.

Year	Mallard		Blue-winged teal		Wood ducks		Other ducks		Total ducks		Canada geese	
1973	106,956	103,106	185,361	209,437	6,636	9,687	113,753	86,448	412,706	406,702		
1974	94,322	101,965	254,440	216,175	15,442	15,098	70,978	66,083	435,182	407,322		
1975	120,460	104,756	237,426	207,800	26,520	21,809	42,472	48,489	426,878	393,977		
1976	109,862	100,603	200,649	190,347	26,164	23,440	42,851	40,402	379,526	364,364		
1977	91,657	93,219	195,737	171,935	21,475	21,962	14,411	29,579	323,280	330,451		
1978	61,646	86,209	134,205	146,583	17,811	21,281	57,686	40,869	271,348	301,350		
1979	78,600	91,796	120,892	129,761	31,697	27,517	34,541	36,869	265,730	290,361		
1980	116,488	103,769	69,404	115,576	29,261	27,875	32,920	35,490	248,073	289,471		
1981	142,831	111,431	258,054	130,107	40,817	29,222	63,336	38,800	505,038	318,437		
1982	89,472	105,669	98,641	103,882	9,524	15,839	21,081	24,018	218,718	260,887		
1983	119,462	108,593	60,465	85,921	10,642	16,515	11,727	16,871	202,296	237,906		
1984	104,759	106,362	64,951	80,728	28,294	26,572	11,991	15,050	209,995	234,191		
1985	73,909	103,599	84,199	81,396	25,757	32,862	8,929	14,521	192,794	240,646		
1986	110,763	116,229	51,266	78,280	82,747	63,084	17,237	19,332	262,013	276,550	11,129	12,701
1987	136,947	131,762	124,021	89,540	98,349	76,139	30,518	26,477	389,835	324,112	14,519	15,360
1988	148,901	146,216	67,580	87,611	54,260	61,352	16,333	28,941	287,074	336,189	15,339	18,879
1989	180,676	161,120	125,062	94,355	59,676	63,744	97,099	55,568	462,513	384,333	53,040	32,725
1990	151,356	168,061	70,169	89,659	67,065	70,153	40,040	55,569	328,630	390,952	22,840	26,354
1991	172,423	183,200	67,023	93,615	69,349	77,277	126,986	83,307	435,781	439,889	23,931	27,330
1992	249,727	205,344	179,125	113,104	145,118	108,108	109,834	81,053	683,804	501,559	34,668	32,949
1993	174,531	209,578	98,859	109,128	73,866	83,863	32,115	56,057	379,371	473,970	34,386	35,959
1994	283,400	234,316	144,041	112,312	63,078	80,867	80,710	68,721	571,229	516,326	36,125	40,618
1995	242,166	240,006	117,945	103,027	153,658	116,557	78,650	69,396	592,419	529,174	59,240	53,525
1996	314,413	246,667	69,960	89,217	76,475	94,613	75,457	62,271	536,305	509,779	55,888	59,617
1997	180,968	226,461	70,795	84,975	119,410	113,676	38,140	45,598	409,313	474,241	78,566	73,463
1998	186,891	229,405	75,975	86,376	121,713	119,080	28,219	37,755	412,798	475,637	74,712	80,516
1999	248,446	254,329	84,418	90,272	113,898	119,756	29,869	37,832	476,631	511,914	101,183	98,050
2000	453,979	287,169	117,338	95,955	141,882	132,947	31,191	41,798	744,390	575,232	129,508	114,308
2001	183,453	259,909	77,310	91,494	131,051	131,253	48,312	56,765	440,126	550,293	94,066	109,531
2002	378,542	282,939	66,033	92,763	135,129	130,087	161,087	92,678	740,791	605,758	118,476	129,199
2003	261,332	266,343	90,136	107,786	110,109	118,411	71,888	80,437	533,465	588,930	241,930	176,613
2004	229,175	254,064	213,755	136,542	114,550	120,245	94,014	84,443	651,494	610,942	149,003	149,988
2005	317,224	255,696	195,239	140,582	141,152	130,228	70,655	75,964	724,270	613,106	123,836	134,678
2006	219,494	231,819	108,701	126,457	121,650	120,006	72,726	73,682	522,571	558,899	134,683	134,467
2007	210,219	217,861	124,093	124,120	87,875	104,659	48,427	68,997	470,614	529,859	125,195	130,102
2008	188,429	205,955	179,549	123,304	126,440	118,214	132,506	90,527	626,924	543,070	116,715	128,952
2009	200,497	201,708	112,793	103,018	113,523	114,595	75,602	75,569	502,416	506,253	148,293	144,663
2010	199,107	197,862	50,188	83,790	103,769	112,814	32,757	61,512	385,821	470,878	157,622	154,061
2011	187,862	193,262	90,803	84,700	146,471	127,297	88,610	84,465	513,746	489,760	176,095	161,074
2012	196,950	190,180	105,791	81,738	106,626	109,340	111,712	105,757	521,079	492,076	145,386	148,913
2013	181,200	183,392	73,483	69,854	91,516	98,734	181,141	125,851	527,340	478,493	138,925	140,452
2014	158,747	176,495	34,337	57,744	104,140	98,944	97,875	102,906	395,099	436,191	126,299	132,046
2015	176,200	177,348	59,083	58,216	68,142	83,971	69,415	89,696	372,840	418,269	119,212	129,481
2016	164,147	177,603	37,936	56,489	89,775	93,401	98,640	96,689	390,498	423,854	129,562	137,234
2017	180,930	183,837	85,526	63,938	102,397	101,603	110,246	98,375	479,099	449,761	158,023	152,577
2018	216,652	192,317	45,130	61,230	100,055	104,512	77,560	85,259	439,397	454,083	157,950	159,117
2019	204,296	189,572	61,946	66,225	100,027	111,663	47,392	75,864	413,661	462,936	171,407	167,102
2020		181,932		73,360		144,265		98,281		502,660		171,530
2021	147,373	173,015	75,256	80,145	240,293	179,989	122,036	122,499	584,958	543,374	170,125	171,075
2022	185,616	176,977	105,116	90,638	157,621	144,254	198,745	156,095	647,098	564,738	171,125	171,667
2023	166,651	175,895	117,085	96,271	73,467	102,381	147,406	153,295	504,609	545,065	155,292	169,447
Long-term mean (1973–2022)	182,315	178,621	110,616	105,224	86,182	85,388	68,784	65,309	447,897	441,802	106,083	106,943
10-year mean (2013–2023)	178,181	180,762	69,490	70,374	112,743	114,883	115,046	109,528	475,460	479,948	149,792	154,703
% change from previous year	-10.2%	-0.6%	11.4%	6.2%	-53.4%	-29.0%	-25.8%	-1.8%	-22.0%	-3.5%	-9.3%	-1.3%
% change from 1973–2022	-8.6%	-1.5%	5.8%	-8.5%	-14.8%	19.9%	114.3%	134.7%	12.7%	23.4%	46.4%	58.4%

Table 7: Annual statewide estimates of breeding Trumpeter swan abundance in Wisconsin, 2010–2023. Survey estimates (corrected for bird density and survey region area, but not visibility) and model-predicted estimates from a Bayesian state-space model are shown. Note that surveys were not conducted in 2020 due to the COVID-19 pandemic.

Year	Survey estimate	Modeled estimate
2010	1,237	1,199
2011	1,408	1,480
2012	1,999	1,896
2013	2,292	2,318
2014	2,979	2,891
2015	3,679	3,564
2016	5,029	4,447
2017	4,833	5,012
2018	5,677	5,873
2019	6,106	6,894
2020		8,882
2021	11,197	10,521
2022	11,919	12,044
2023	11,078	13,643

Figures

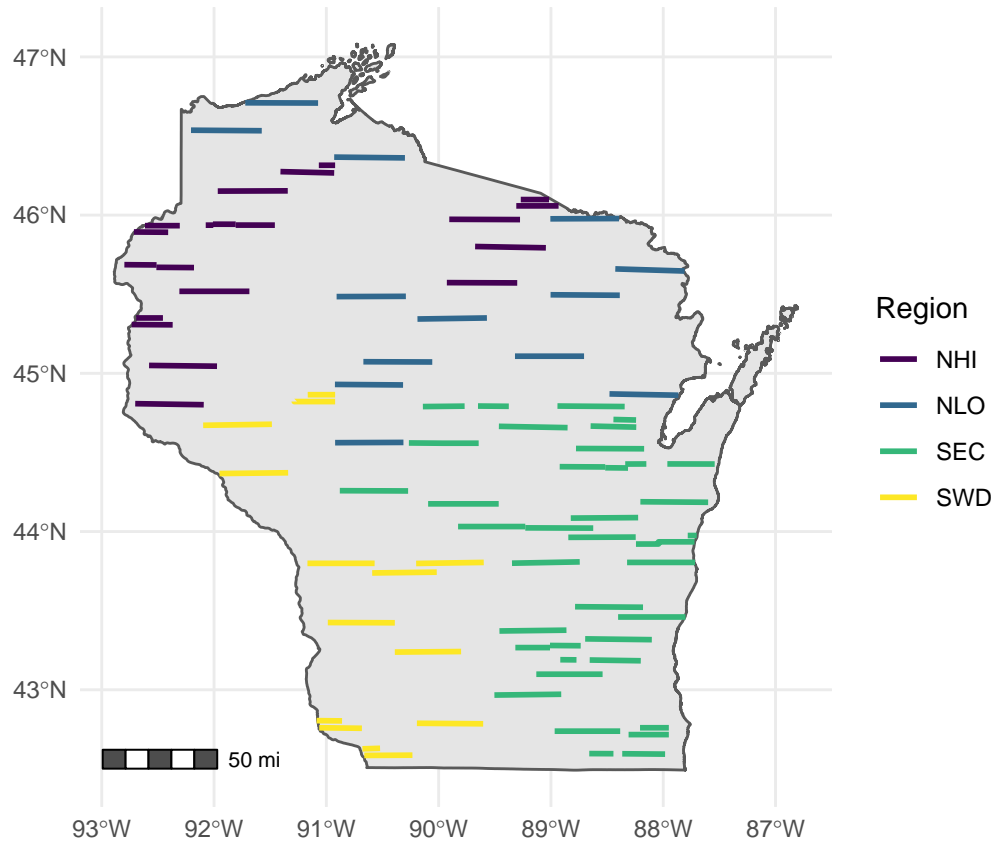


Figure 1: Wisconsin Waterfowl Breeding Population Survey aerial transects ($n = 66$) labeled by survey region. The four regions surveyed are the Northern High Density region (NHI), Northern Low Density region (NLO), Southeast Central region (SEC), and Southwest Driftless region (SWD).

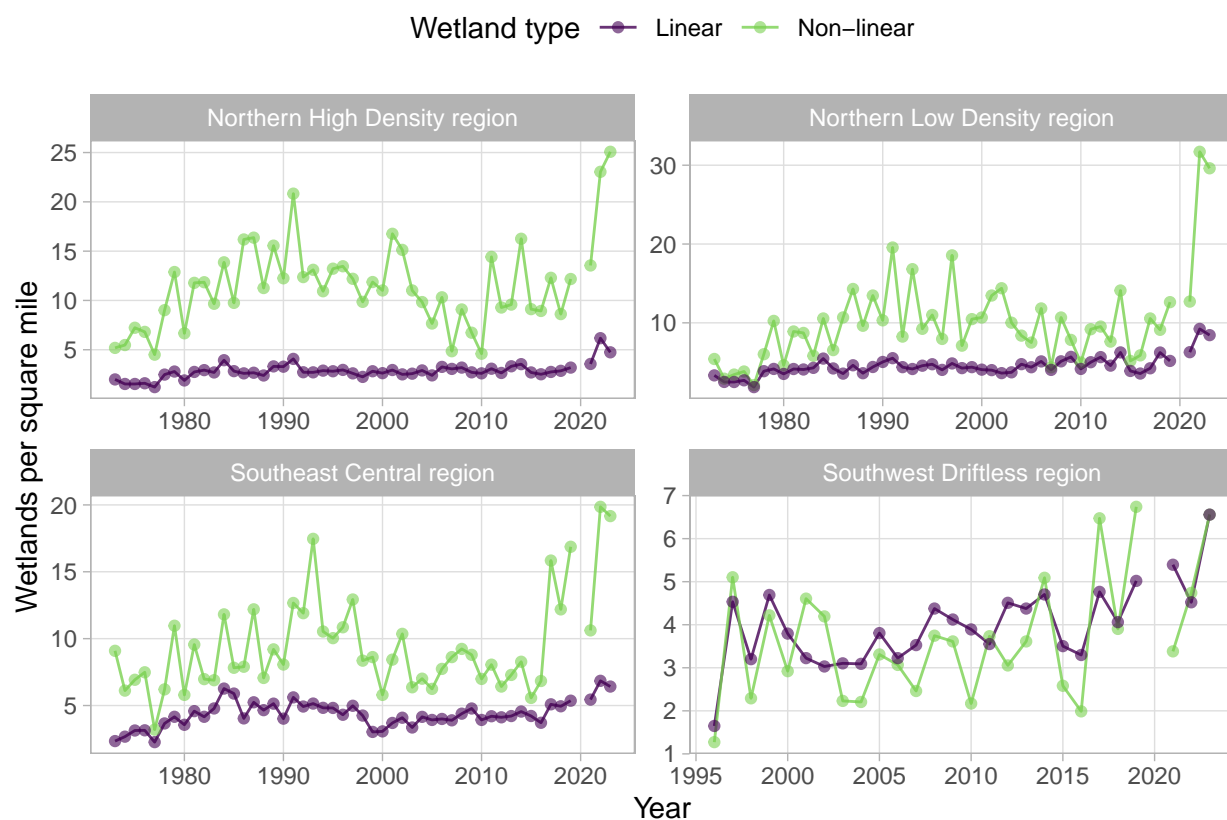


Figure 2: Annual variability in total linear and non-linear wetlands per square mile by survey region. Note that surveys were not conducted in 2020 due to the COVID-19 pandemic.

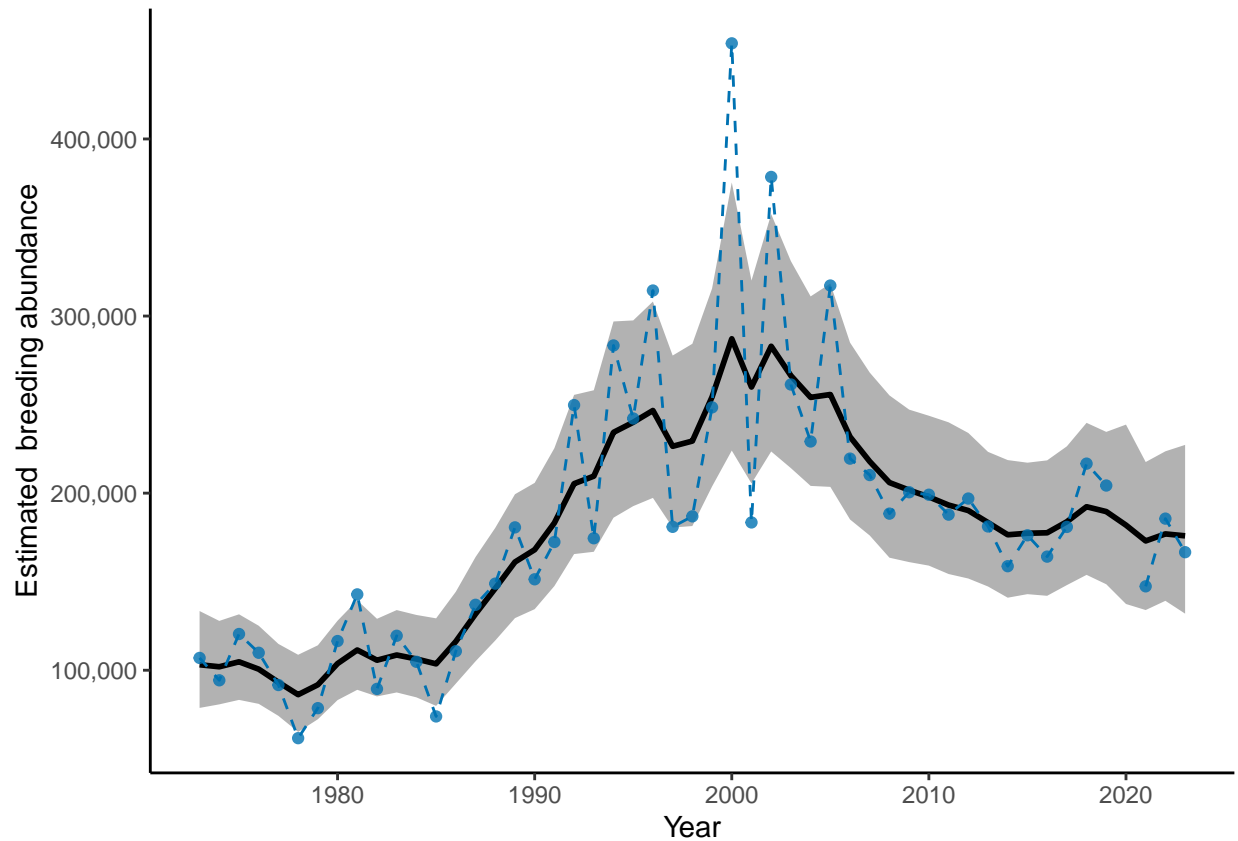


Figure 3: Annual statewide estimates of breeding mallard population size in Wisconsin, 1973–2023. Black line and gray shaded region are the mean and 95% credible interval estimates for the state-space population trend, and blue points and dashed line show the annual survey counts. Note that surveys were not conducted in 2020 due to the COVID-19 pandemic.

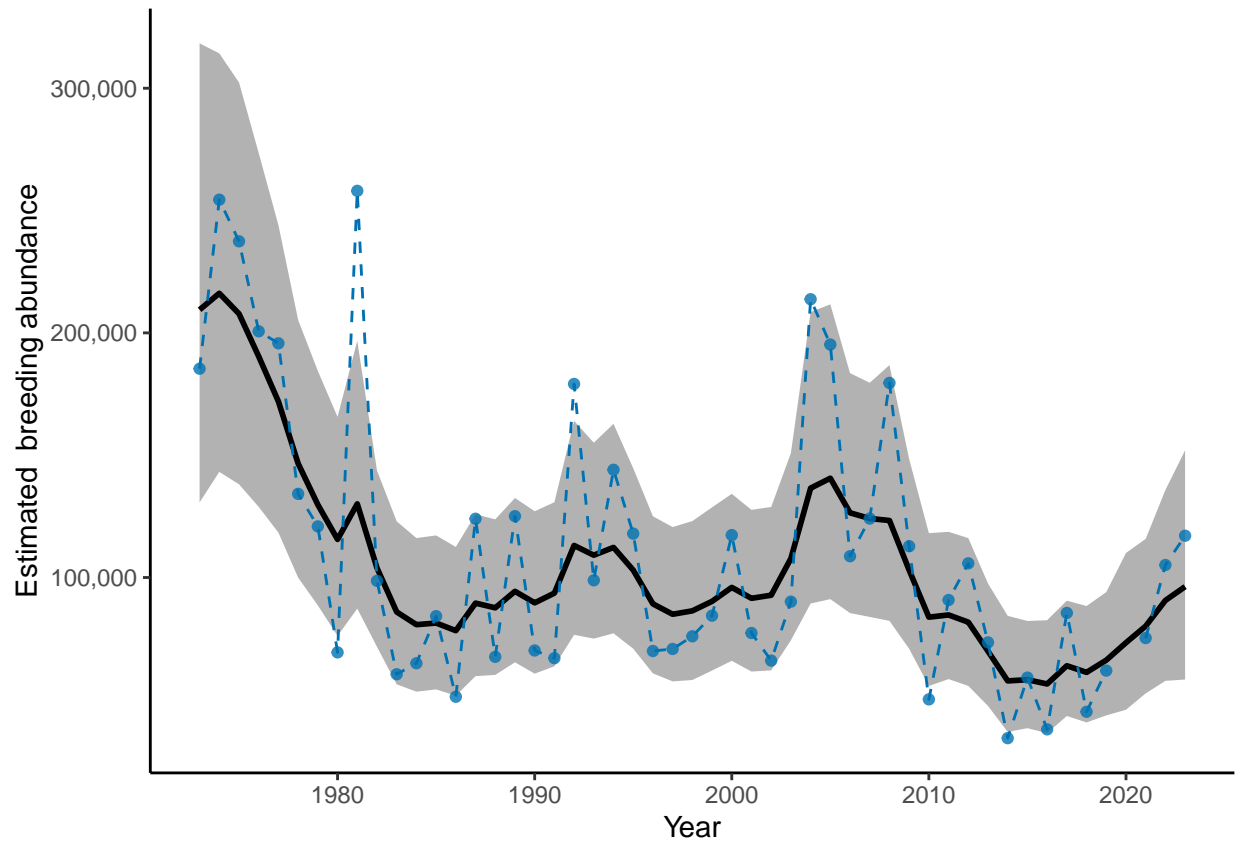


Figure 4: Annual statewide estimates of breeding blue-winged teal abundance in Wisconsin, 1973–2023. Black line and gray shaded region are the mean and 95% credible interval estimates for the state-space population trend, and blue points and dashed line show the annual survey counts. Note that surveys were not conducted in 2020 due to the COVID-19 pandemic.

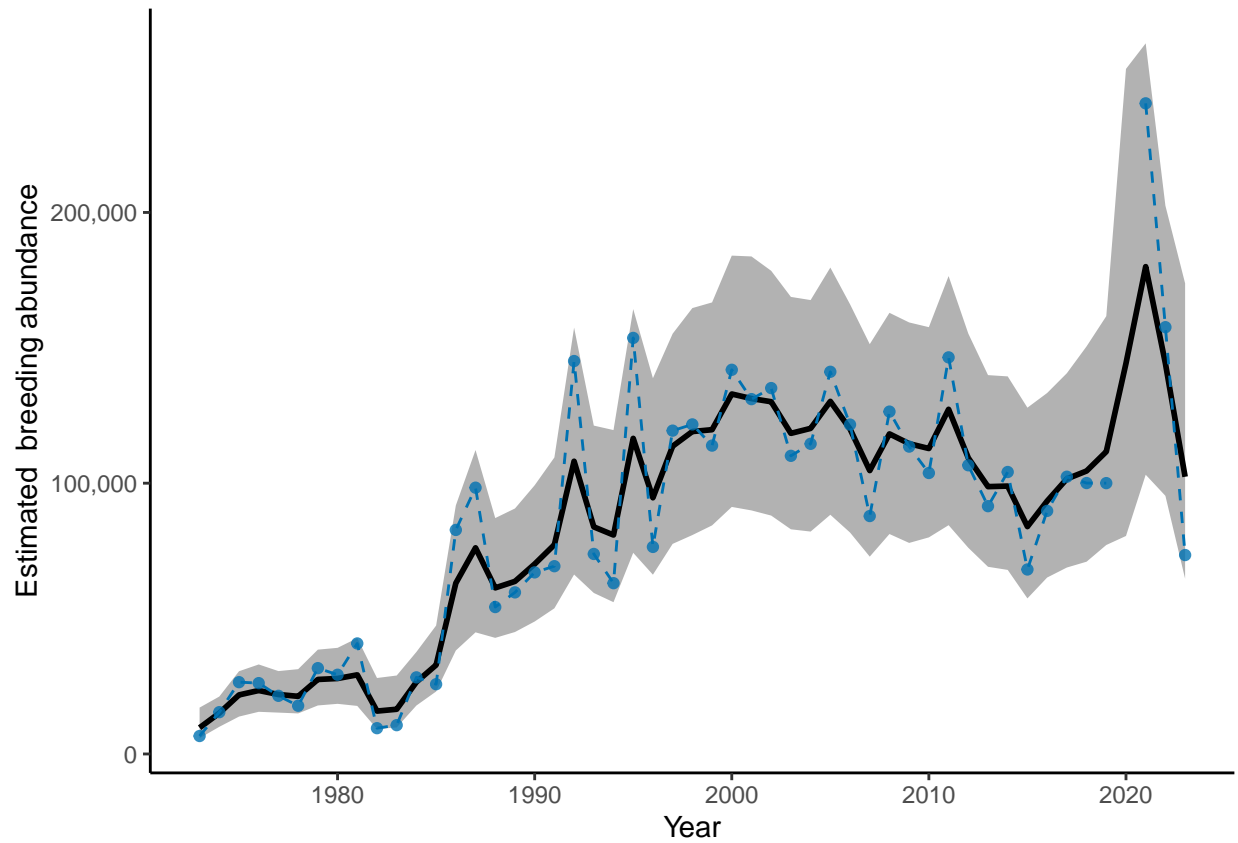


Figure 5: Annual statewide estimates of breeding wood duck abundance in Wisconsin, 1973–2023. Black line and gray shaded region are the mean and 95% credible interval estimates for the state-space population trend, and blue points and dashed line show the annual survey counts. Note that surveys were not conducted in 2020 due to the COVID-19 pandemic.

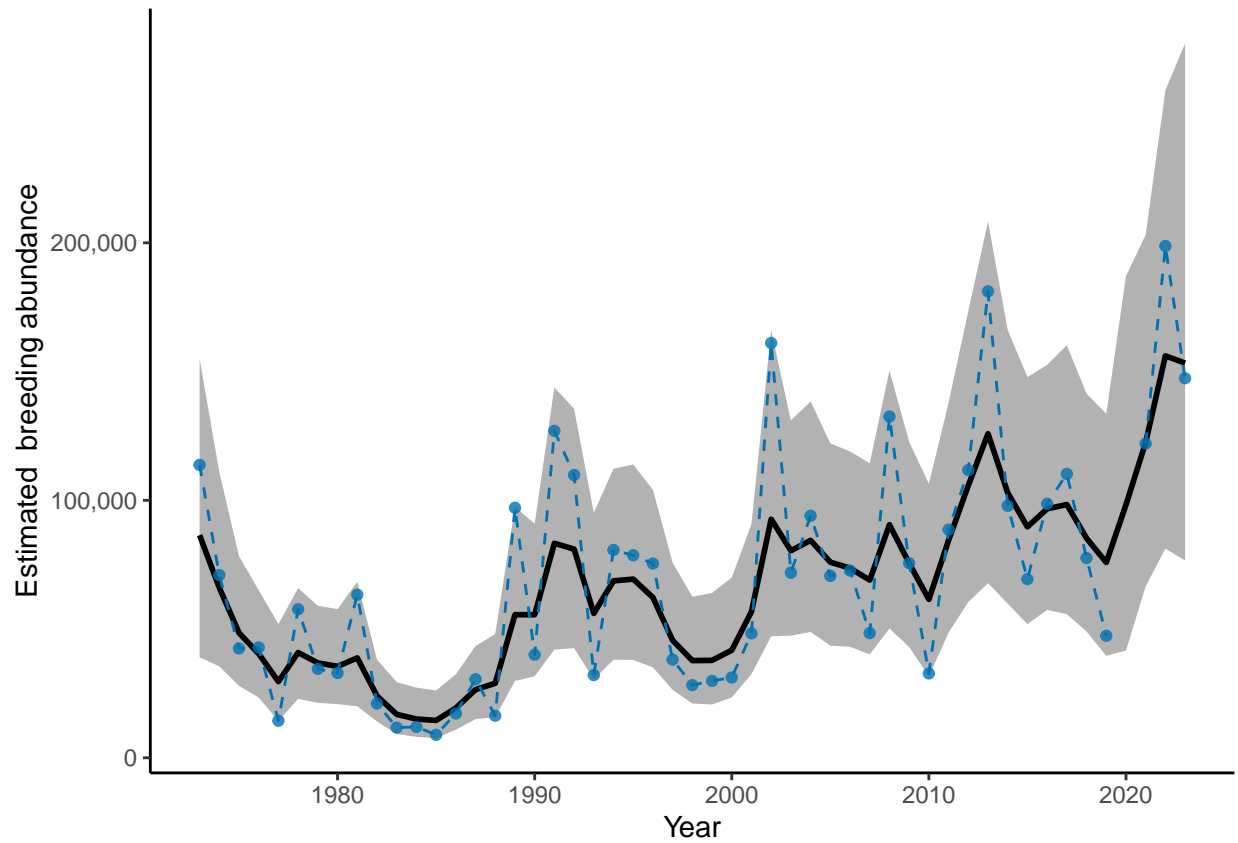


Figure 6: Annual statewide estimates of breeding ‘other duck’ abundance in Wisconsin, 1973–2023. Black line and gray shaded region are the mean and 95% credible interval estimates for the state-space population trend, and blue points and dashed line show the annual survey counts. Note that surveys were not conducted in 2020 due to the COVID-19 pandemic.

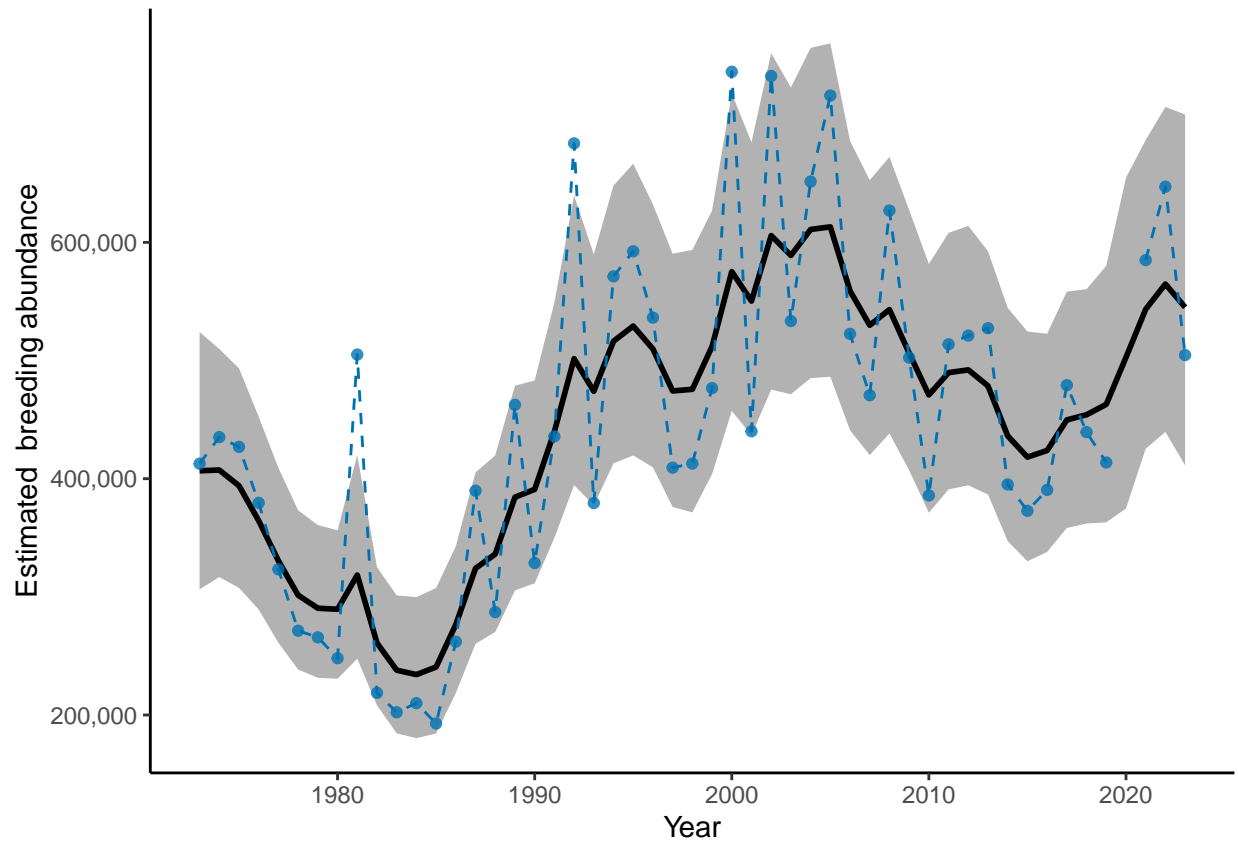


Figure 7: Annual statewide estimates of total breeding duck abundance in Wisconsin, 1973–2023. Black line and gray shaded region are the mean and 95% credible interval estimates for the state-space population trend, and blue points and dashed line show the annual survey counts. Note that surveys were not conducted in 2020 due to the COVID-19 pandemic.

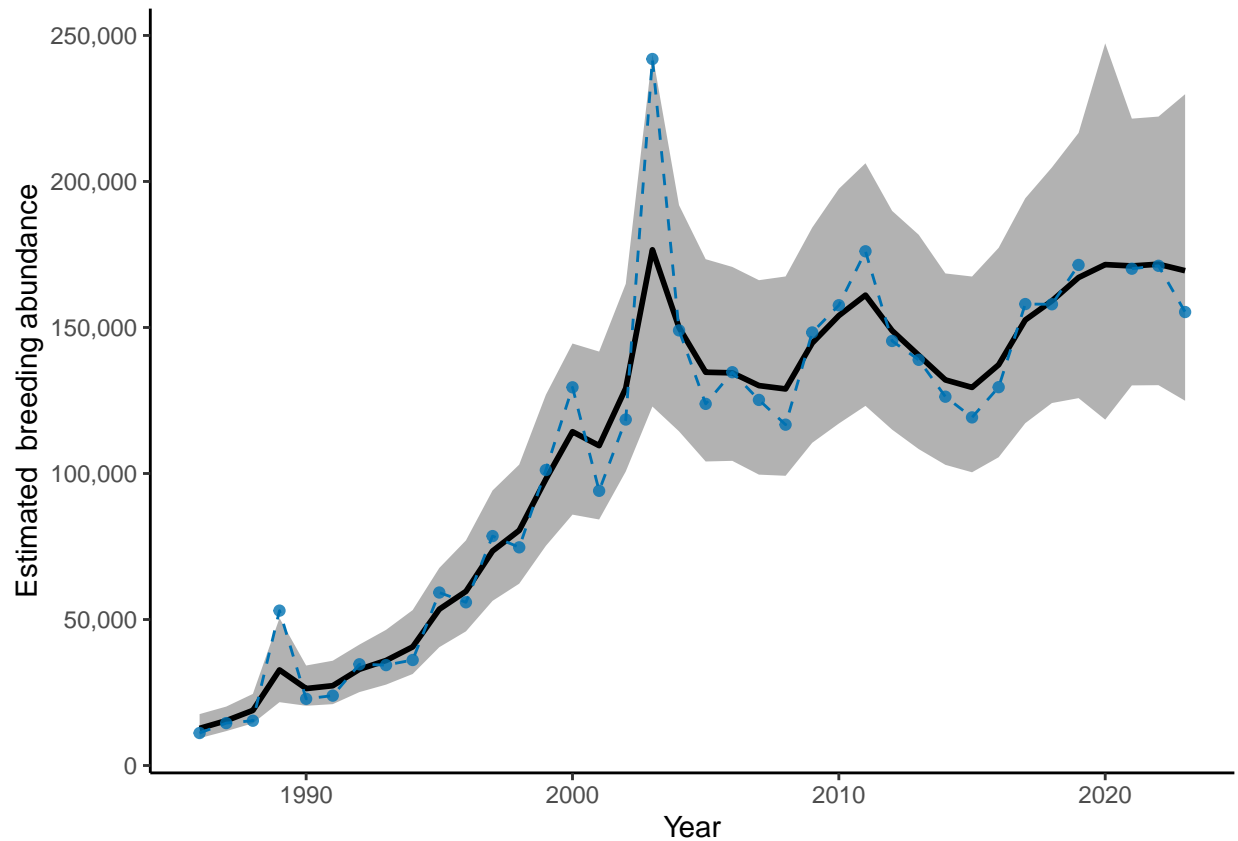


Figure 8: Annual statewide estimates of breeding Canada goose abundance in Wisconsin, 1986–2023. Black line and gray shaded region are the mean and 95% credible interval estimates for the state-space population trend, and blue points and dashed line show the annual survey counts. Note that surveys were not conducted in 2020 due to the COVID-19 pandemic.

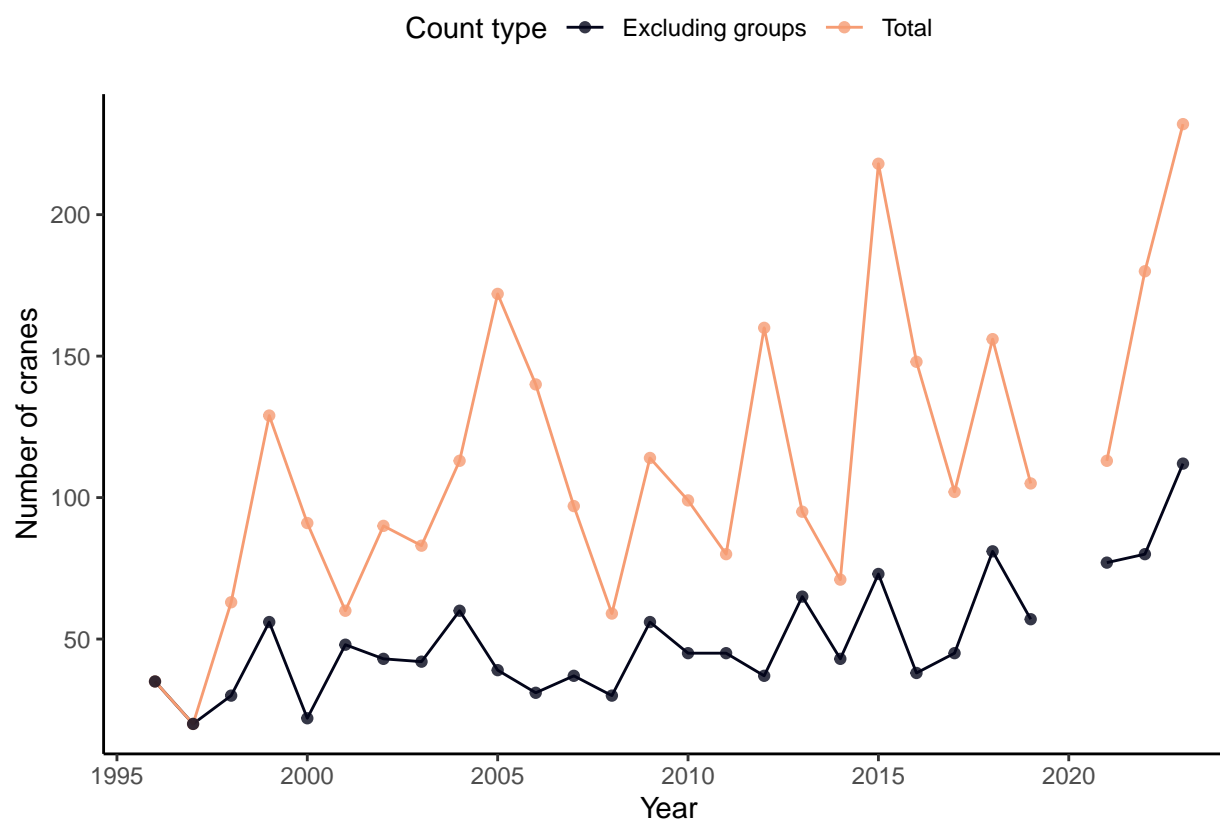


Figure 9: Annual counts of sandhill cranes (raw estimates) observed from the air during the Waterfowl Breeding Population Survey, 1996–2023. Note that surveys were not conducted in 2020 due to the COVID-19 pandemic.

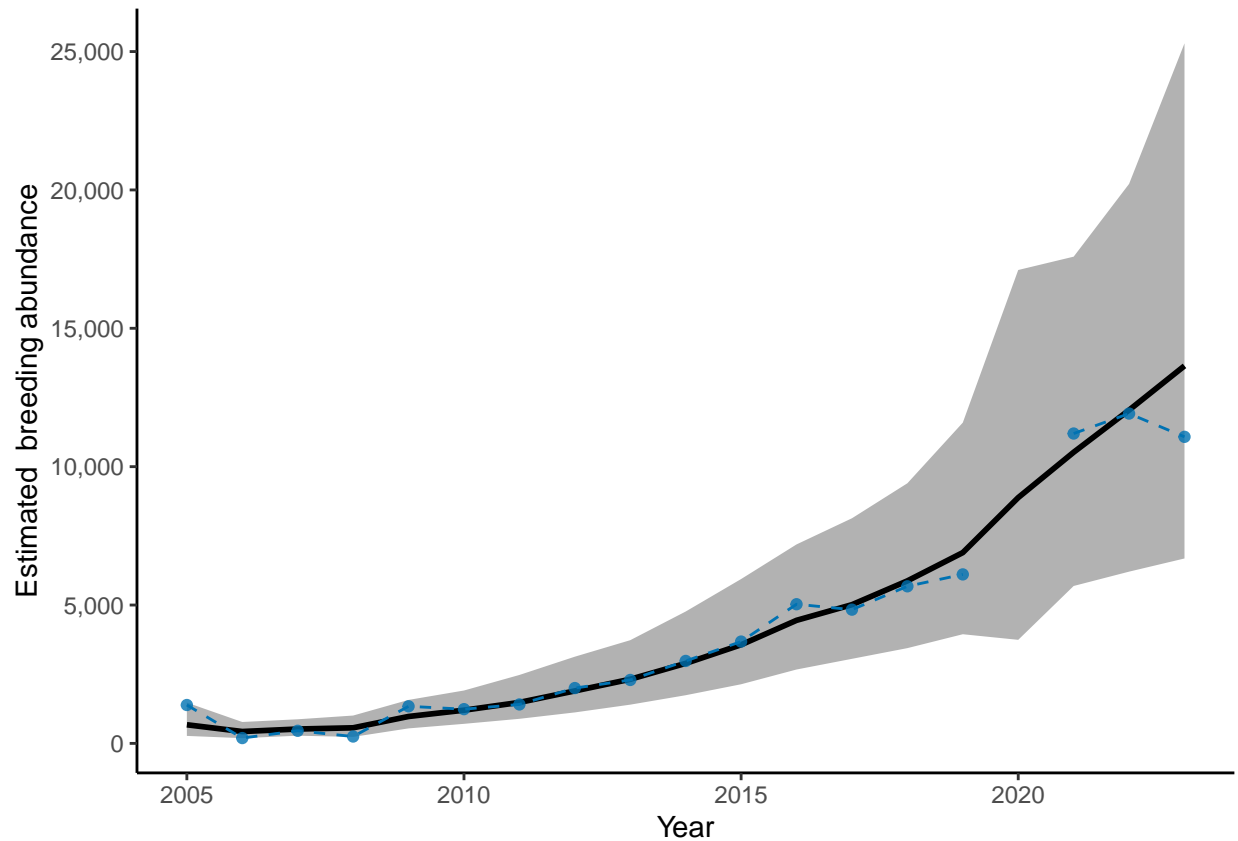


Figure 10: Annual statewide estimates of trumpeter swan abundance in Wisconsin, 2005–2023. Black line and gray shaded region are the mean and 95% credible interval estimates for the state-space population trend, and blue points and dashed line show the annual survey counts. Note that surveys were not conducted in 2020 due to the COVID-19 pandemic.