

WISCONSIN DEPARTMENT OF NATURAL RESOURCES
Waterfowl Breeding Population Survey For Wisconsin, 1973–2022

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Abstract

The 2022 Waterfowl Breeding Population Survey for Wisconsin was conducted from April 25–May 6 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 up 87.1% from 2021 in the Southeast Central (SEC) region and up 116.2% from the long-term, 49-year mean. In the Northern High Density (NHI) region, total non-linear basins were up 70.1% from 2021 and up 105.9% from the long-term mean. Non-linear basins were up 149.7% from 2021 in the Northern Low Density (NLO) region and up 224.5% from the long-term mean. Non-linear basins were up 40.1% from 2021 in the Southwest Driftless (SWD) region and up 32.9% compared to this region's long-term (25-year) mean. Total linear basins were up 25.8% from 2021 in the SEC region and up 58.6% from the long-term mean. In the NHI region, linear basins were up 73.5% from 2021 and up 120.3% from the long-term mean. NLO region linear basins were up 47.1% from 2021 and up 108.0% from the long-term mean. Linear basins were down 16.2% from 2021 in the SWD region and up 16.4% from the long-term mean.

The 2022 total breeding duck modeled population estimate of 591,762 was 6.3% higher than the 2021 modeled estimate of 556,507, and was 33.6% higher than the long-term mean. Overall, the total duck population estimate for 2022 was higher than what we have experienced over the last few years (2015–2019) and above the total duck numbers experienced in the prior 10 years. The mallard modeled breeding population estimate of 181,686 was 3.3% higher than the 2021 estimate of 175,819 and was 1.5% higher than the

long-term mean. The blue-winged teal modeled breeding population estimate of 81,359 was 9.0% higher compared to the 2021 estimate of 74,653, but remains 22.1% lower than the long-term mean. At 174,526 the 2022 population estimate for wood ducks was 8.4% lower than the 2021 estimate of 190,551 and 102.2% higher than the long-term mean. The modeled Canada goose population estimate of 180,340 was 3.3% higher compared to the 2021 estimate of 174,515, and 68.2% higher than the long-term mean. The population estimate of “other ducks” was 156,330, which was 26.4% higher than the 2021 estimate of 123,648 and was 138.8% 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 68 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 2022 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-geese 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.*’

Results

Survey timing

We initiated the 2022 Waterfowl Breeding Population Survey on April 25. 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 was a slight issue leading up to and during the survey, with extremely wet conditions across most of the state and cold conditions in the north, resulting in northern Wisconsin lakes retaining some ice into late April/early May. Significant rainfall events likely contributed to the high number of temporary and other wetland types recorded across much of the state.

Aerial surveys were completed in 9 days from April 25 to May 5. The ground survey was completed in 10 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 up 87.1% from 2021 and were up 116.2% from the long-term (49-year) mean. Linear basins in the SEC region were up 25.8% from 2021 and up 58.6% from the long-term mean (Table 1). In the NHI region, total non-linear basins were up 70.1% from 2021 and up 105.9% from the long-term mean. Linear basins in the NHI region were up 73.5% from 2021 and up 120.3% from the long-term mean (Table 2). In the NLO region, total non-linear basins were up 149.7% from 2021 and up 224.5% from the long-term mean. Linear basins in the NLO region were up 47.1% from 2021 and up 108.0% from the long-term mean (Table 3). In the SWD region, total non-linear basins were up 40.1% from 2021 and up 32.9% from this region’s long-term, 25-year mean. Linear basins in the SWD region were down 16.2% from 2021 and up 16.4% from the long-term mean (Table 4). Long-term wetland counts for each survey region are shown in Figure 2.

Waterfowl population estimates

2022 VCF and population estimate summary statistics for mallards, blue-winged teal, wood ducks, “other ducks”, and Canada geese are provided in Table 5.

Mallards

The 2022 modeled mallard population estimate was **181,686 (95% credible interval [CI] = 136,200–237,762 individuals)**. This estimate is 3.3% higher compared to the previous year's modeled estimate and 1.5% higher than the long-term, 49-year mean (Table 6; Figure 3). As in previous years, the SEC still represented the largest portion of the breeding mallard population (46%) and was similar to that of 2021.

Blue-winged teal

The 2022 modeled population estimate for blue-winged teal was **81,359 (95% CI = 48,810–129,071 individuals)**. This estimate was 9.0% higher compared to the previous year's modeled estimate but remains 22.1% lower than the long-term mean (Table 6; Figure 4).

Wood ducks

The 2022 population estimate for wood ducks was **174,526 (95% CI = 111,751–262,979 individuals)**. This estimate was 8.4% lower compared to the previous year and was 102.2% higher than the long-term mean (Table 6; Figure 5). The breeding wood duck population showed significant gains in the 1980s and early 1990s and appears to be leveling off around 100,000 after peaking about 10 years ago but has shown an increasing trend over the past five years.

Other ducks

The 2022 modeled population estimate for “other ducks” was **156,330 (95% CI = 73,792–285,474 individuals)**. This estimate was 26.4% higher compared to the previous year and was 138.8% higher than the long-term mean (Table 6; Figure 6). Species considered as “other ducks” and their percent composition in the 2022 uncorrected aerial count were: American black duck (*A. rubripes*; 0%), northern pintail (*A. acuta*; 3%), gadwall (*Mareca strepera*; 0%), American wigeon (*M. americana*; 0%), northern shoveler (*Spatula clypeata*; 10%), green-winged teal (*A. carolinensis*; 4%), canvasback (*A. valisineria*; 2%), redhead (*A. americana*; 0%), ring-necked duck (*A. collaris*; 36%), common goldeneye (*B. clangula*; 10%), hooded merganser (*Lophodytes cucullatus*; 7%), common merganser (*Mergus merganser*; 24%), red-breasted merganser (*M. serrator*; 0%), and ruddy duck (*Oxyura jamaicensis*; 3%).

Total ducks

The 2022 population estimate for all breeding ducks was **591,762 (95% CI = 440,343–767,764 individuals)**. This estimate was 6.3% higher compared to the previous year and is 33.6% 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 2022 population estimate for Canada geese was **180,340 (95% CI = 132,921–245,447 individuals)**. This estimate was 3.3% higher than the previous year's modeled estimate and was 68.2% higher than the long-term, 36-year mean (Table 6; Figure 8). The long-term trend in goose numbers suggests a continued, gradual increase in their population.

American coots, sandhill cranes, and trumpeter swans

In 2022, observers counted a total of 422 coots, one pair of whooping cranes, and 80 sandhill cranes (Figure 9). Excluding groups of five or more, 115 trumpeter swans were recorded and the 2022 population estimate (accounting for bird density and survey region area, but lacking VCF-correction) was **13,320 (95% CI = 6,582–23,888 individuals)**; Table 7; Figure 10).

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Tables

Table 1: Type and number of wetlands per square mile observed during the last 10-year period, 2012–2022, SEC region.

Year	Wetland type							
	I, II, VI	III	IV, V	VII, VIII	Non-linear	Stream	Ditch	Linear
2012	2.1	0.6	3.1	0.7	6.4	1.6	2.6	4.1
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
% Change from previous year	222.0%	147.5%	2.8%	72.8%	87.1%	1.4%	48.8%	25.8%
Long-term mean	3.9	0.9	3.0	1.1	9.0	1.8	2.5	4.3
% Change from long-term mean	140.5%	143.9%	71.0%	173.1%	121.6%	51.9%	66.7%	60.5%
10-Year mean (2012-2022)	4.7	1.1	3.7	1.5	11.0	1.9	3.0	4.8

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 2: Type and number of wetlands per square mile observed during the last 10-year period, 2012–2022, NHI region.

Year	Wetland type							
	I, II, VI	III	IV, V	VII, VIII	Non-linear	Stream	Ditch	Linear
2012	3.4	1.0	3.8	1.0	9.3	2.3	0.3	2.6
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
% Change from previous year	131.6%	200.9%	-11.5%	116.2%	70.1%	49.4%	303.0%	73.5%
Long-term mean	3.4	1.4	4.0	2.2	10.9	2.3	0.4	2.7
% Change from long-term mean	-4.7%	145.7%	27.0%	425.8%	110.6%	109.8%	210.4%	125.9%
10-Year mean (2012-2022)	3.0	1.7	4.5	3.1	12.3	2.7	0.6	3.3

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, 2012–2022, NLO region.

Year	Wetland type							
	I, II, VI	III	IV, V	VII, VIII	Non-linear	Stream	Ditch	Linear
2012	5.0	0.5	2.4	1.7	9.5	4.8	0.8	5.7
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
% Change from previous year	353.2%	29.2%	-11.2%	179.8%	149.7%	12.9%	173.8%	47.1%
Long-term mean	4.1	0.8	2.3	2.1	9.3	3.5	0.8	4.3
% Change from long-term mean	233.5%	84.4%	49.8%	518.4%	240.4%	58.3%	349.8%	112.8%
10-Year mean (2012-2022)	5.1	0.9	2.6	3.3	11.9	4.1	1.4	5.5

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 4: Type and number of wetlands per square mile observed during the last 10-year period, 2012–2022, SWD region.

Year	Wetland type							
	I, II, VI	III	IV, V	VII, VIII	Non-linear	Stream	Ditch	Linear
2012	1.0	0.2	1.9	0.0	3.1	3.6	1.0	4.5
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
% Change from previous year	142.0%	34.3%	-37.3%	442.9%	40.1%	-28.9%	84.0%	-16.2%
Long-term mean	1.4	0.3	1.6	0.3	3.5	3.2	0.7	3.9
% Change from long-term mean	48.6%	72.3%	-21.4%	243.6%	34.7%	6.7%	67.4%	17.2%
10-Year mean (2012-2022)	1.7	0.5	1.6	0.4	4.2	3.4	1.0	4.4

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 2022 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	3.899	1.210	84,668	15,307
NHI	9,431	3.179	1.210	36,279	6,960
NLO	15,979	2.421	1.210	46,795	10,943
SWD	12,311	1.200	1.210	17,874	4,038
Subtotal				185,616	20,465
Blue-winged teal					
SEC	17,949	0.566	5.443	55,253	15,708
NHI	9,431	0.431	5.443	22,114	12,724
NLO	15,979	0.226	5.443	19,626	12,599
SWD	12,311	0.121	5.443	8,123	6,600
Subtotal				105,116	24,717
Wood duck					
SEC	17,949	1.255	2.793	62,926	15,568
NHI	9,431	1.108	2.793	29,179	7,778
NLO	15,979	0.646	2.793	28,838	10,873
SWD	12,311	1.067	2.793	36,678	14,336
Subtotal				157,621	25,032
Other duck species^a					
SEC	17,949	0.961	3.807	65,655	18,406
NHI	9,431	2.533	3.807	90,947	23,752
NLO	15,979	0.646	3.807	39,303	11,928
SWD	12,311	0.061	3.807	2,840	1,992
Subtotal				198,745	32,392
Canada goose					
SEC	17,949	3.113	1.676	93,623	14,953
NHI	9,431	1.579	1.676	24,962	5,719
NLO	15,979	1.159	1.676	31,034	8,834
SWD	12,311	1.042	1.676	21,506	7,757
Subtotal				171,125	19,862

^{*} 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 2022, aerial visibility correction factors for mallards, blue-winged teal, wood ducks, Canada geese, and "other ducks" were derived using 1, 14, 4, 1, and 11 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, 1973–2022.

Year	Mallard		Blue-winged teal		Wood ducks		Other ducks		Total ducks		Canada geese	
1973	106,956	103,069	185,361	208,627	6,636	9,775	113,753	87,580	412,706	406,167		
1974	94,322	101,784	254,440	213,215	15,442	14,951	70,978	66,567	435,182	407,851		
1975	120,460	104,645	237,426	205,289	26,520	21,447	42,472	49,071	426,878	395,222		
1976	109,862	100,722	200,649	187,930	26,164	23,416	42,851	40,417	379,526	364,864		
1977	91,657	93,178	195,737	170,196	21,475	22,215	14,411	29,944	323,280	330,295		
1978	61,646	85,781	134,205	145,456	17,811	21,691	57,686	40,473	271,348	300,150		
1979	78,600	91,477	120,892	129,312	31,697	27,344	34,541	36,903	265,730	287,986		
1980	116,488	104,163	69,404	115,596	29,261	27,631	32,920	35,835	248,073	288,296		
1981	142,831	111,602	258,054	127,636	40,817	28,164	63,336	38,416	505,038	321,242		
1982	89,472	105,259	98,641	104,383	9,524	16,211	21,081	24,064	218,718	260,338		
1983	119,462	108,384	60,465	87,594	10,642	16,773	11,727	17,034	202,296	236,258		
1984	104,759	106,225	64,951	81,993	28,294	26,227	11,991	15,217	209,995	233,835		
1985	73,909	103,071	84,199	82,017	25,757	33,042	8,929	14,768	192,794	239,341		
1986	110,763	116,045	51,266	79,493	82,747	60,397	17,237	19,582	262,013	275,724	11,129	12,649
1987	136,947	132,308	124,021	89,842	98,349	73,144	30,518	26,406	389,835	323,542	14,519	15,340
1988	148,901	146,422	67,580	87,999	54,260	61,277	16,333	29,254	287,074	335,140	15,339	18,818
1989	180,676	161,279	125,062	95,076	59,676	63,499	97,099	54,962	462,513	384,374	53,040	32,672
1990	151,356	167,342	70,169	90,535	67,065	69,611	40,040	55,572	328,630	389,481	22,840	26,193
1991	172,423	182,671	67,023	94,084	69,349	77,219	126,986	81,919	435,781	440,541	23,931	27,165
1992	249,727	206,017	179,125	111,263	145,118	103,469	109,834	79,010	683,804	505,617	34,668	33,041
1993	174,531	209,629	98,859	108,234	73,866	83,946	32,115	56,476	379,371	473,274	34,386	36,030
1994	283,400	235,823	144,041	111,549	63,078	82,094	80,710	68,488	571,229	516,628	36,125	40,617
1995	242,166	241,247	117,945	102,764	153,658	114,147	78,650	68,838	592,419	532,076	59,240	53,529
1996	314,413	248,368	69,960	89,596	76,475	95,856	75,457	61,826	536,305	507,841	55,888	59,273
1997	180,968	226,560	70,795	85,641	119,410	113,156	38,140	45,308	409,313	470,130	78,566	73,245
1998	186,891	229,336	75,975	86,678	121,713	118,734	28,219	38,052	412,798	472,997	74,712	80,056
1999	248,446	255,518	84,418	90,595	113,898	120,551	29,869	37,814	476,631	511,084	101,183	97,504
2000	453,979	289,300	117,338	95,919	141,882	132,687	31,191	42,477	744,390	577,468	129,508	113,692
2001	183,453	260,321	77,310	91,722	131,051	131,030	48,312	56,865	440,126	549,324	94,066	108,687
2002	378,542	283,449	66,033	93,618	135,129	129,631	161,087	92,051	740,791	607,645	118,476	128,850
2003	261,332	266,693	90,136	107,515	110,109	119,391	71,888	81,721	533,465	590,276	241,930	177,107
2004	229,175	254,612	213,755	133,259	114,550	120,976	94,014	84,450	651,494	614,367	149,003	149,542
2005	317,224	256,664	195,239	137,560	141,152	129,170	70,655	76,904	724,270	618,069	123,836	134,005
2006	219,494	232,642	108,701	125,826	121,650	118,984	72,726	74,065	522,571	560,999	134,683	134,412
2007	210,219	217,859	124,093	123,415	87,875	105,552	48,427	69,933	470,614	532,626	125,195	129,678
2008	188,429	206,185	179,549	121,168	126,440	117,960	132,506	90,317	626,924	544,484	116,715	129,134
2009	200,497	201,839	112,793	102,963	113,523	115,791	75,602	76,141	502,416	504,730	148,293	145,177
2010	199,107	197,565	50,188	84,109	103,769	113,191	32,757	61,597	385,821	468,296	157,622	153,860
2011	187,862	192,949	90,803	83,706	146,471	125,200	88,610	84,007	513,746	489,523	176,095	160,724
2012	196,950	190,364	105,791	80,989	106,626	109,728	111,712	104,739	521,079	492,936	145,386	148,308
2013	181,200	183,222	73,483	69,884	91,516	99,415	181,141	125,914	527,340	478,437	138,925	140,216
2014	158,747	175,816	34,337	58,088	104,140	98,897	97,875	103,760	395,099	436,365	126,299	132,346
2015	176,200	176,752	59,083	58,238	68,142	84,898	69,415	89,920	372,840	419,012	119,212	129,060
2016	164,147	177,809	37,936	56,220	89,775	93,850	98,640	96,713	390,498	426,914	129,562	136,932
2017	180,930	184,545	85,526	62,260	102,397	102,611	110,246	98,330	479,099	451,343	158,023	152,529
2018	216,652	193,550	45,130	60,281	100,055	106,837	77,560	86,210	439,397	454,147	157,950	159,248
2019	204,296	191,517	61,946	64,598	100,027	116,286	47,392	77,528	413,661	463,912	171,407	168,727
2020		183,728		69,998		152,129		99,976		510,252		174,039
2021	147,373	175,819	75,256	74,653	240,293	190,551	122,036	123,648	584,958	556,507	170,125	174,515
2022	185,616	181,686	105,116	81,359	157,621	174,526	198,745	156,330	647,098	591,762	171,125	180,340
Mean (1973–2021)	182,247	179,003	110,731	104,869	84,693	84,505	66,077	63,613	443,747	439,958	104,225	105,192
Mean (2013–2022)	179,462	182,444	64,201	65,558	117,107	122,000	111,450	105,833	472,221	478,865	149,181	154,795
% change from previous year	25.9%	3.3%	39.7%	9.0%	-34.4%	-8.4%	62.9%	26.4%	10.6%	6.3%	0.6%	3.3%
% change from 1973–2021	1.8%	1.5%	-5.1%	-22.4%	86.1%	106.5%	200.8%	145.8%	45.8%	34.5%	64.2%	71.4%

Table 7: Annual statewide estimates of breeding Trumpeter swan abundance in Wisconsin, 2010–2022. 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	1,203
2011	1,408	1,468
2012	1,999	1,883
2013	2,292	2,315
2014	2,979	2,906
2015	3,679	3,582
2016	5,029	4,469
2017	4,833	5,076
2018	5,677	6,019
2019	6,106	7,147
2020		9,303
2021	11,197	11,160
2022	11,919	13,320

Figures

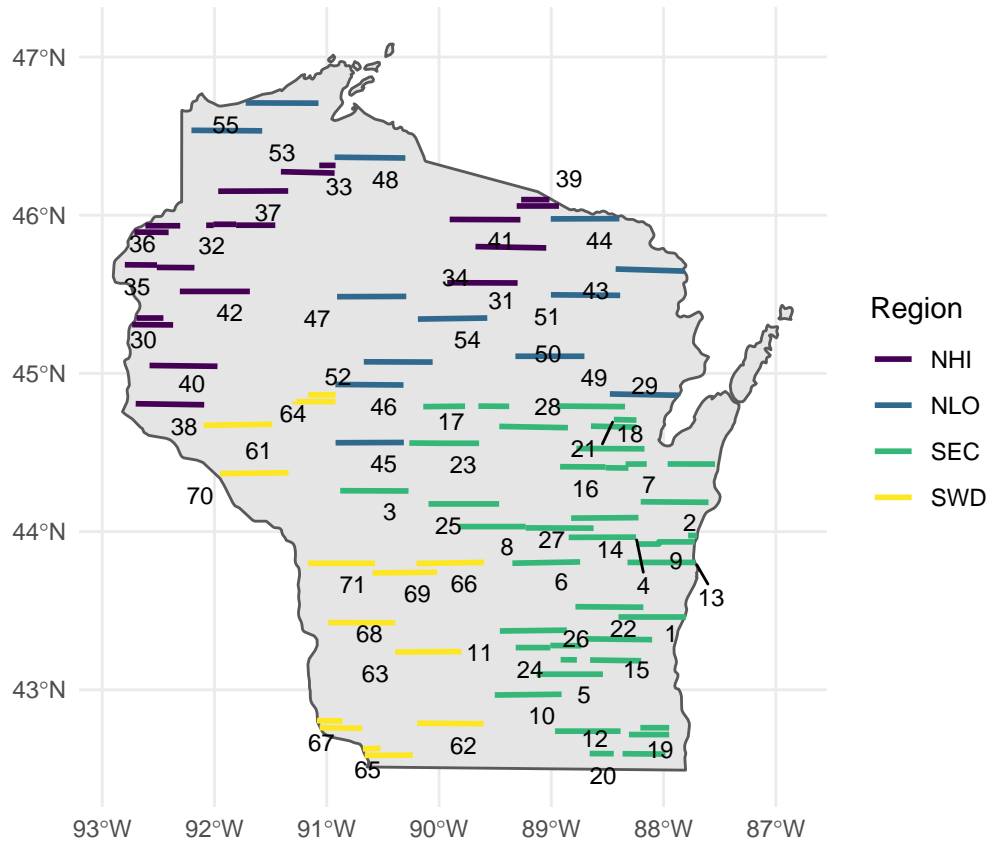


Figure 1: Wisconsin Waterfowl Breeding Population Survey aerial transects ($n = 66$) labeled by transect number and survey region. The four regions surveyed are the Northern High Density region (NHI), Northern Low Density region (NLO), Southeast Central region (SEC), and Southwest Driftless region (SWD).

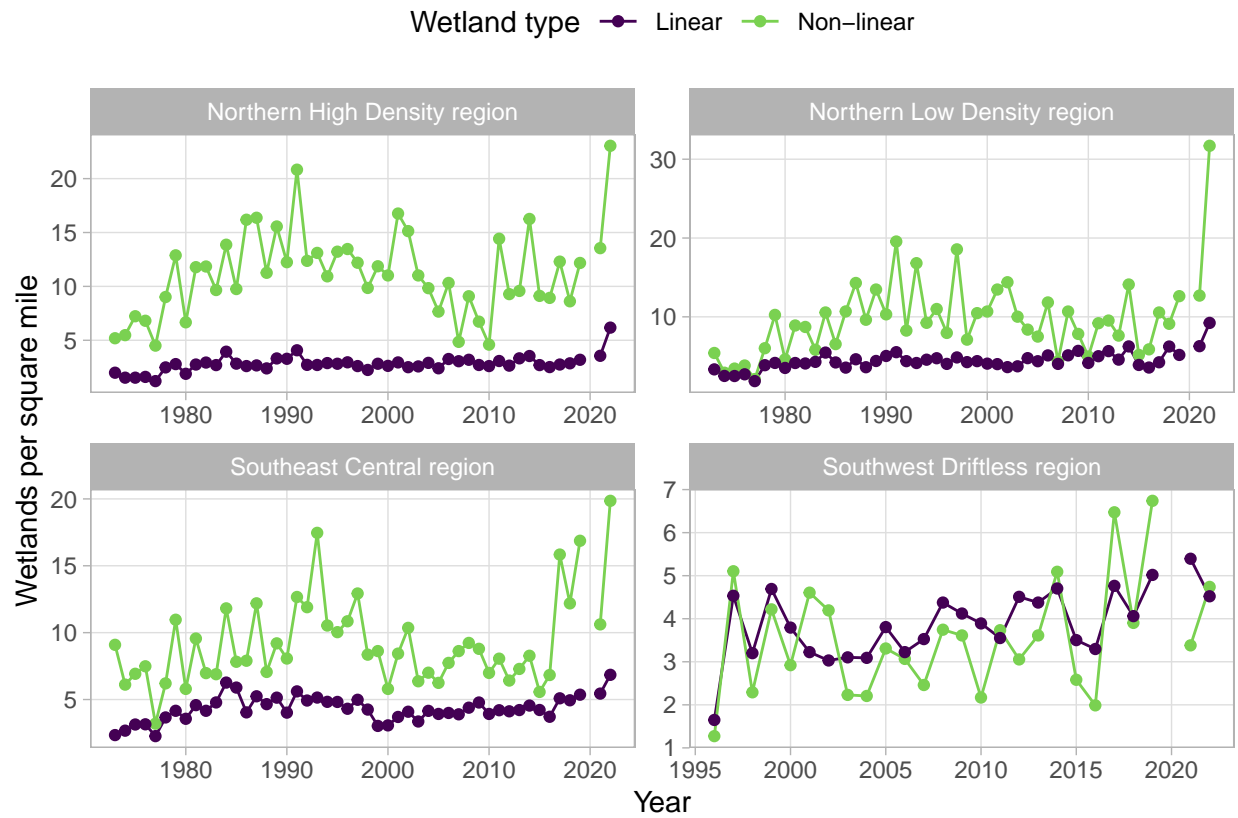


Figure 2: Annual variability in total linear and non-linear wetlands per square mile by survey region. Note that surveys were not conducted in 2020 due to the COVID-19 pandemic.

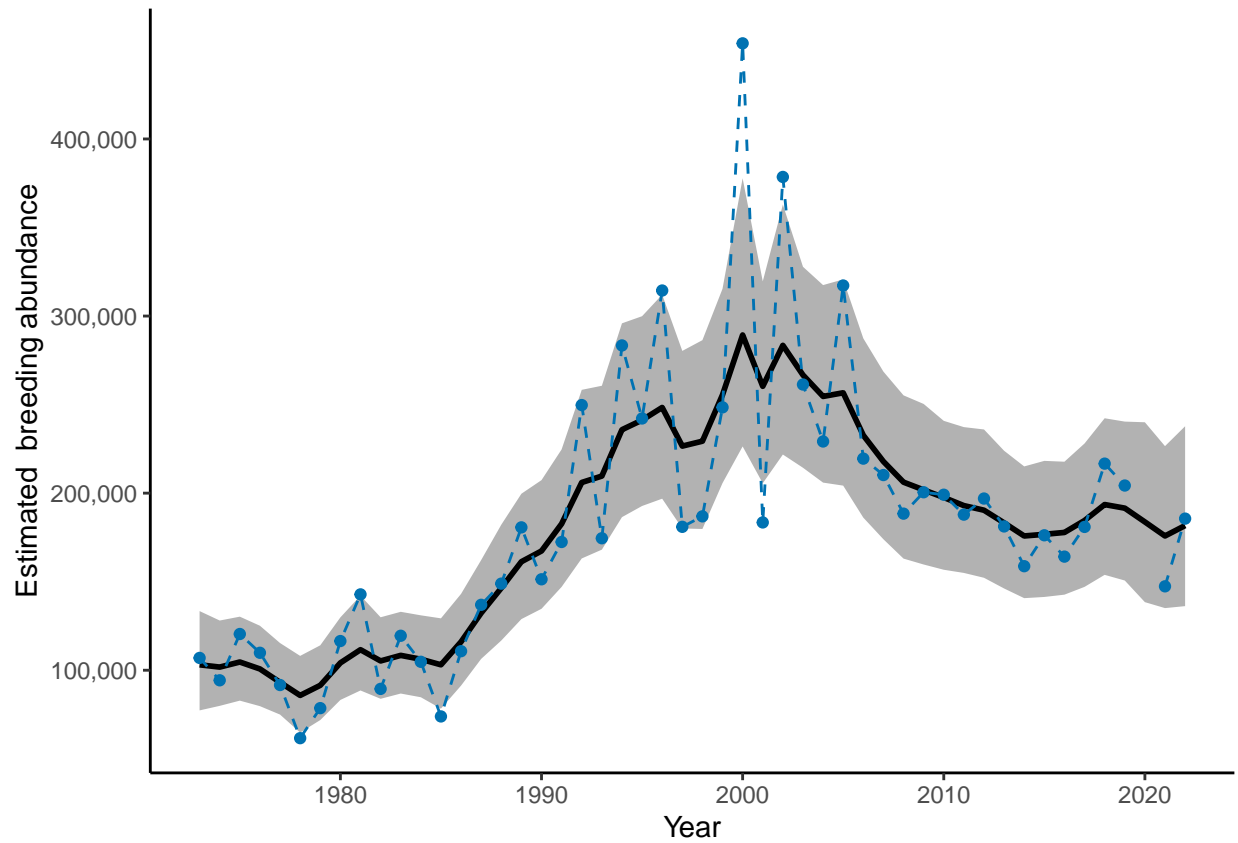


Figure 3: Annual statewide estimates of breeding mallard population size in Wisconsin, 1973–2022. Black line and gray shaded region are the mean and 95% credible interval estimates for the state-space population trend, and blue points and dashed line show the annual survey counts. Note that surveys were not conducted in 2020 due to the COVID-19 pandemic.

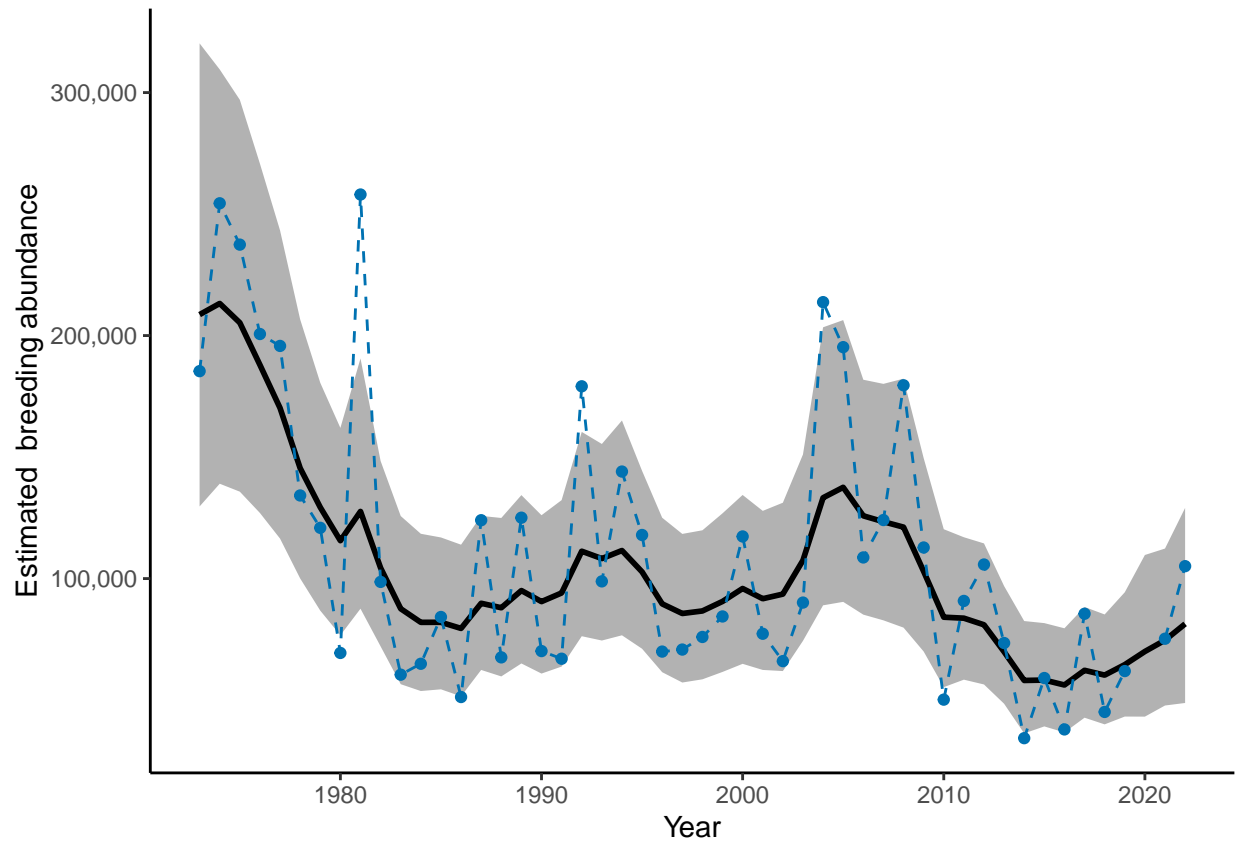


Figure 4: Annual statewide estimates of breeding blue-winged teal abundance in Wisconsin, 1973–2022. Black line and gray shaded region are the mean and 95% credible interval estimates for the state-space population trend, and blue points and dashed line show the annual survey counts. Note that surveys were not conducted in 2020 due to the COVID-19 pandemic.

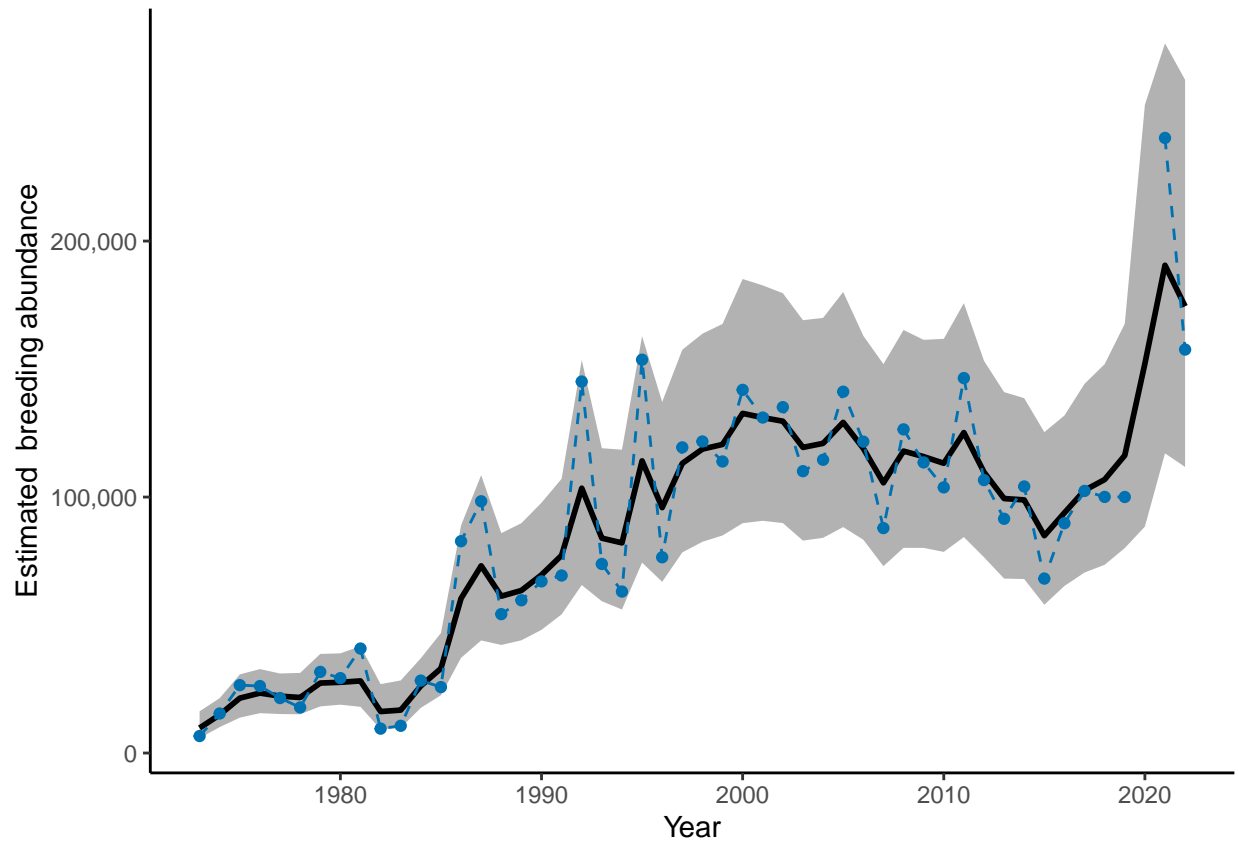


Figure 5: Annual statewide estimates of breeding wood duck abundance in Wisconsin, 1973–2022. Black line and gray shaded region are the mean and 95% credible interval estimates for the state-space population trend, and blue points and dashed line show the annual survey counts. Note that surveys were not conducted in 2020 due to the COVID-19 pandemic.

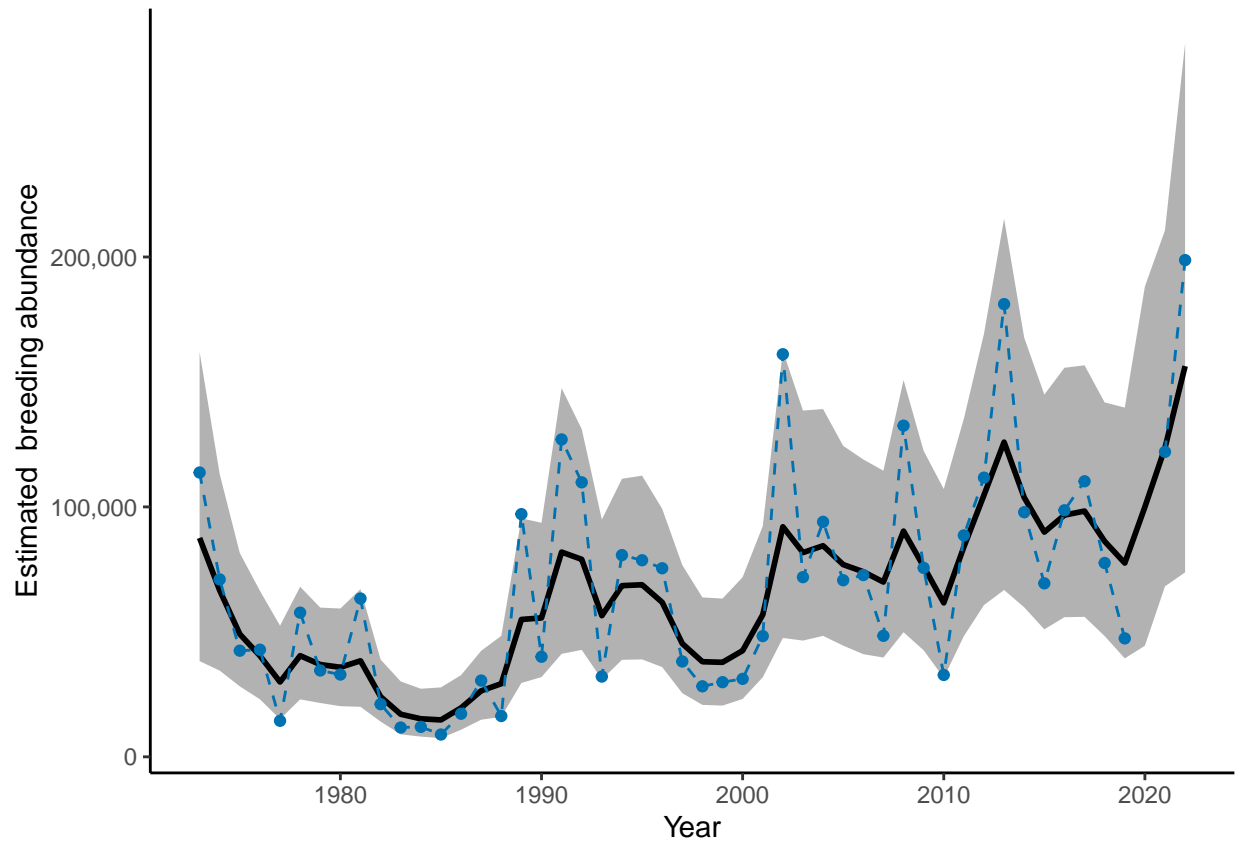


Figure 6: Annual statewide estimates of breeding ‘other duck’ abundance in Wisconsin, 1973–2022. Black line and gray shaded region are the mean and 95% credible interval estimates for the state-space population trend, and blue points and dashed line show the annual survey counts. Note that surveys were not conducted in 2020 due to the COVID-19 pandemic.

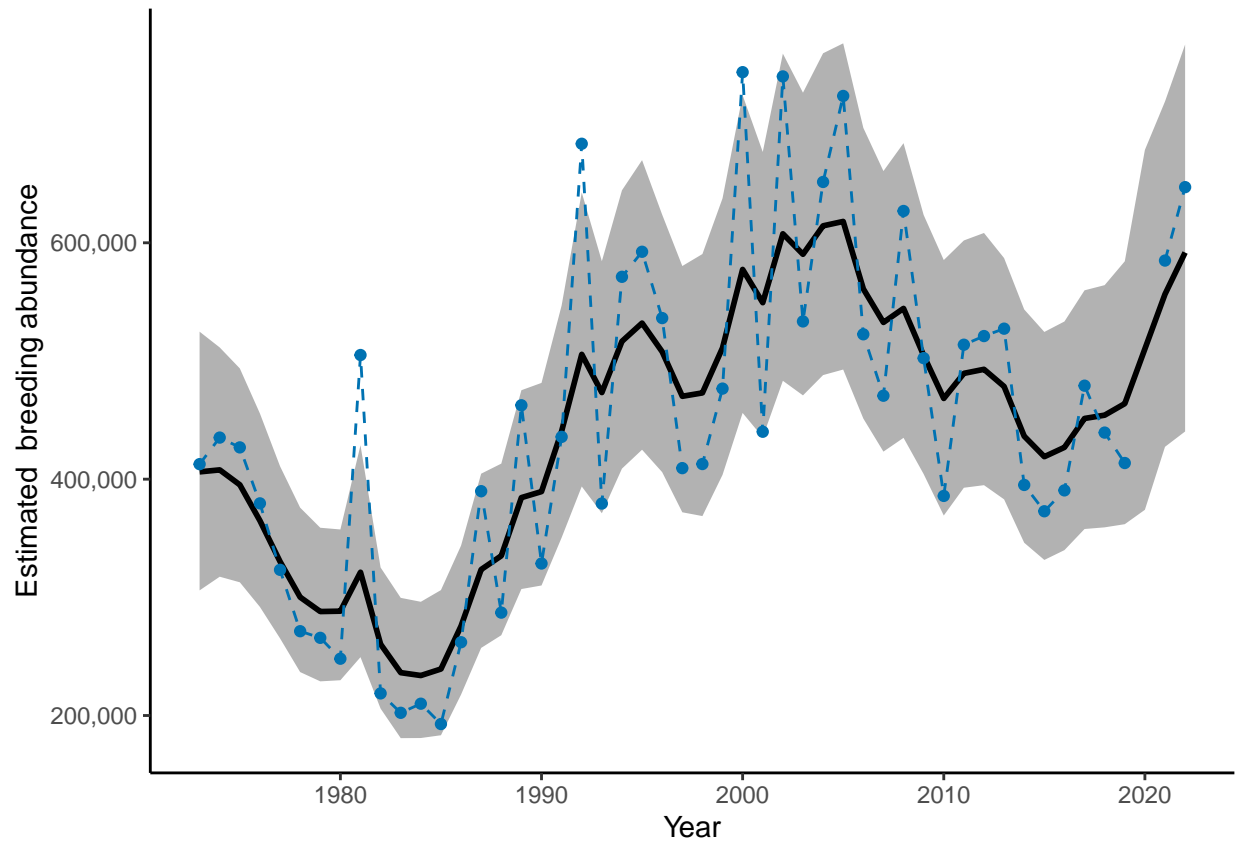


Figure 7: Annual statewide estimates of total breeding duck abundance in Wisconsin, 1973–2022. Black line and gray shaded region are the mean and 95% credible interval estimates for the state-space population trend, and blue points and dashed line show the annual survey counts. Note that surveys were not conducted in 2020 due to the COVID-19 pandemic.

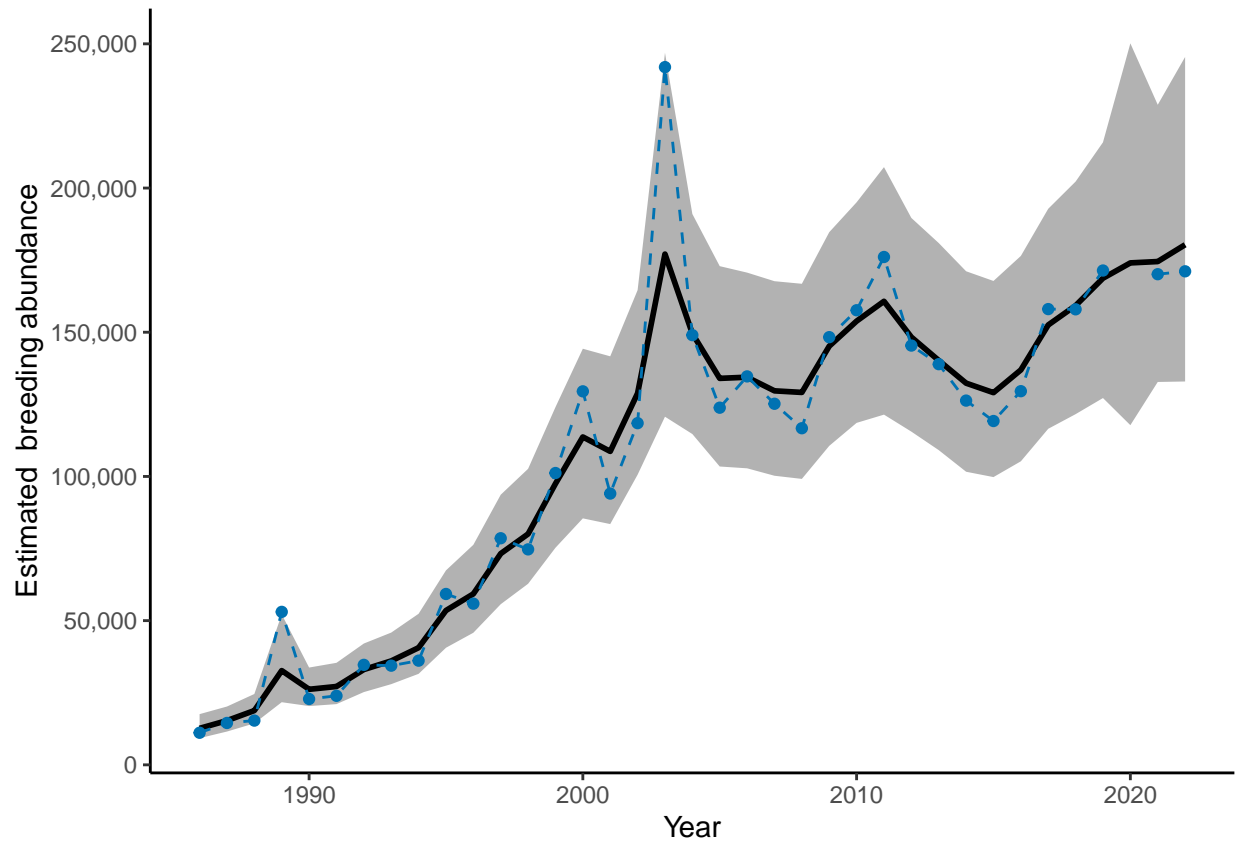


Figure 8: Annual statewide estimates of breeding Canada goose abundance in Wisconsin, 1986–2022. Black line and gray shaded region are the mean and 95% credible interval estimates for the state-space population trend, and blue points and dashed line show the annual survey counts. Note that surveys were not conducted in 2020 due to the COVID-19 pandemic.

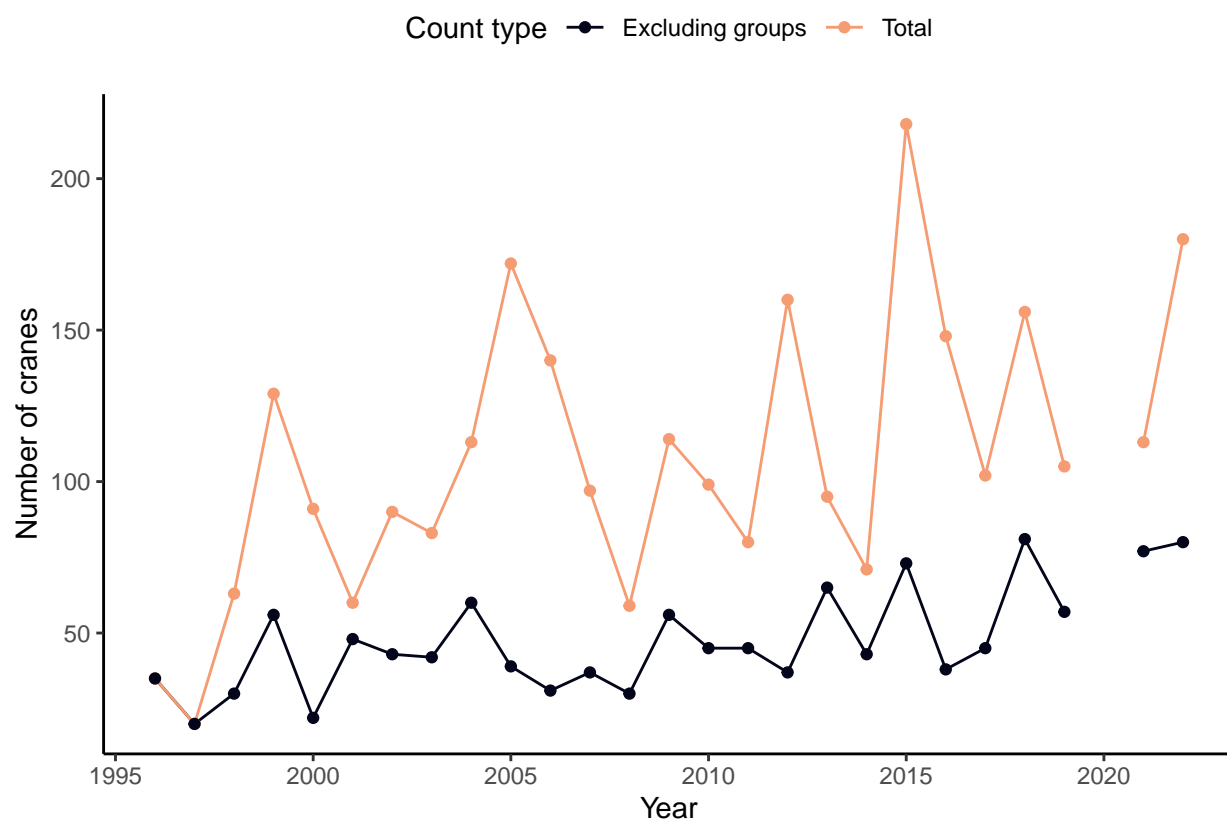


Figure 9: Annual counts of sandhill cranes (raw estimates) observed from the air during the Waterfowl Breeding Population Survey, 1996–2022. Note that surveys were not conducted in 2020 due to the COVID-19 pandemic.

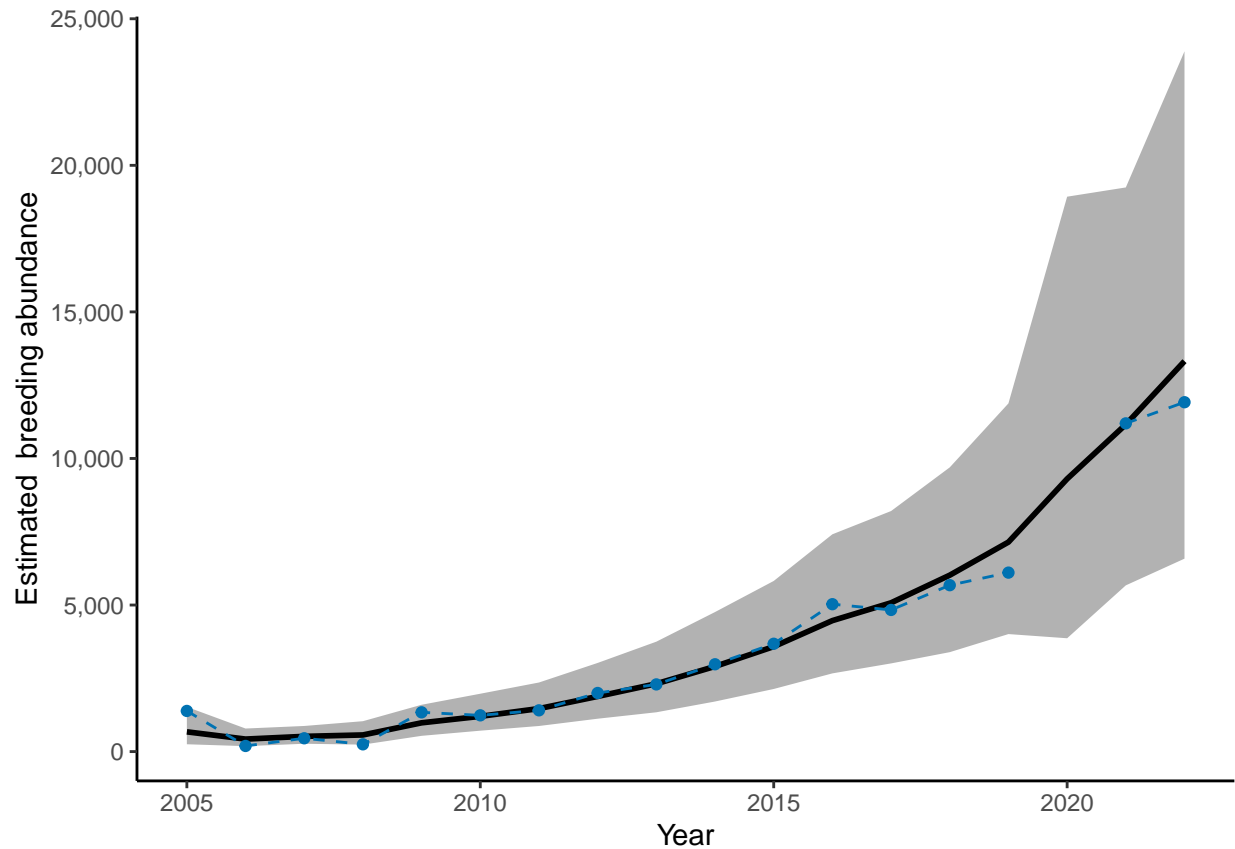


Figure 10: Annual statewide estimates of trumpeter swan abundance in Wisconsin, 2005–2022. Black line and gray shaded region are the mean and 95% credible interval estimates for the state-space population trend, and blue points and dashed line show the annual survey counts. Note that surveys were not conducted in 2020 due to the COVID-19 pandemic.