

WISCONSIN DEPARTMENT OF NATURAL RESOURCES
Waterfowl Breeding Population Survey For Wisconsin, 1973–2021

Drew Fowler¹ and Taylor Finger²

¹*Office of Applied Science*

²*Bureau of Wildlife Management*

Wisconsin Department of Natural Resources

April 2023

Abstract

The 2021 Waterfowl Breeding Population Survey for Wisconsin was conducted from April 26–May 7 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 37.1% from 2019 in the Southeast Central (SEC) region and up 18.5% from the long-term, 48-year mean. In the Northern High Density (NHI) region, total non-linear basins were up 11.3% from 2019 and up 23.8% from the long-term mean. Non-linear basins were up 0.6% from 2019 in the Northern Low Density (NLO) region and up 36.3% from the long-term mean. Non-linear basins were down 49.8% from 2019 in the Southwest Driftless (SWD) region and down 3.9% compared to this region's long-term (24-year) mean. Total linear basins were up 1.5% from 2019 in the SEC region and up 27.7% from the long-term mean. In the NHI region, linear basins were up 11.6% from 2019 and up 30.2% from the long-term mean. NLO region linear basins were up 21.4% from 2019 and up 44.7% from the long-term mean. Linear basins were up 7.5% from 2019 in the SWD region and up 39.8% from the long-term mean.

The 2021 total breeding duck modeled population estimate of 527,766 was 6.8% higher than the 2020 modeled estimate of 494,046, and was 20.4% higher than the long-term mean. Overall, the total duck population estimate for 2021 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 172,151 was 4.9% lower than the 2020 estimate of 181,070 and was 3.7% lower than the

long-term mean. The blue-winged teal modeled breeding population estimate of 65,082 was 2.6% higher compared to the 2020 estimate of 63,440, but remains 37.6% lower than the long-term mean. At 205,206 the 2021 population estimate for wood ducks was 30.4% higher than the 2020 estimate of 157,347 and 141.1% higher than the long-term mean. The modeled Canada goose population estimate of 179,384 was 2.3% higher compared to the 2020 estimate of 175,267, and 69.9% higher than the long-term mean. The population estimate of “other ducks” was 106,879, which was 17.7% higher than the 2020 estimate of 90,780 and was 69.9% 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 67 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 2021 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.*’

Results

Survey timing

We initiated the 2021 Waterfowl Breeding Population Survey on April 26. 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 26 to May 7. The ground survey was completed in 7 days from April 26 to May 7. 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 37.1% from 2019 and were up 18.5% from the long-term (48-year) mean. Linear basins in the SEC region were up 1.5% from 2019 and up 27.7% from the long-term mean (Table 1). In the NHI region, total non-linear basins were up 11.3% from 2019 and up 23.8% from the long-term mean. Linear basins in the NHI region were up 11.6% from 2019 and up 30.2% from the long-term mean (Table 2). In the NLO region, total non-linear basins were up 0.6% from 2019 and up 36.3% from the long-term mean. Linear basins in the NLO region were up 21.4% from 2019 and up 44.7% from the long-term mean (Table 3). In the SWD region, total non-linear basins were down 49.8% from 2019 and down 3.9% from this region’s long-term, 24-year mean. Linear basins in the SWD region were up 7.5% from 2019 and up 39.8% from the long-term mean (Table 4). Long-term wetland counts for each survey region are shown in Figure 2.

Waterfowl population estimates

2021 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 2021 modeled mallard population estimate was **172,151 (95% credible interval [CI] = 124,444–230,409 individuals)**. This estimate is 4.9% lower compared to the previous year's modeled estimate and 3.7% lower than the long-term, 48-year mean (Table 6; Figure 3). As in previous years, the SEC still represented the largest portion of the breeding mallard population (48%) and was similar to that of 2019.

Blue-winged teal

The 2021 modeled population estimate for blue-winged teal was **65,082 (95% CI = 38,631–104,553 individuals)**. This estimate was 2.6% higher compared to the previous year's modeled estimate but remains 37.6% lower than the long-term mean (Table 6; Figure 4).

Wood ducks

The 2021 population estimate for wood ducks was **205,206 (95% CI = 118,136–308,529 individuals)**. This estimate was 30.4% higher compared to the previous year and was 141.1% 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 2021 modeled population estimate for “other ducks” was **106,879 (95% CI = 49,783–203,001 individuals)**. This estimate was 17.7% higher compared to the previous year and was 69.9% higher than the long-term mean (Table 6; Figure 6). Species considered as “other ducks” and their percent composition in the 2021 uncorrected aerial count were: American black duck (*A. rubripes*; 0%), northern pintail (*A. acuta*; 0%), gadwall (*Mareca strepera*; 1%), American wigeon (*M. americana*; 0%), northern shoveler (*Spatula clypeata*; 7%), green-winged teal (*A. carolinensis*; 0%), canvasback (*A. valisineria*; 0%), redhead (*A. americana*; 0%), ring-necked duck (*A. collaris*; 43%), common goldeneye (*B. clangula*; 4%), hooded merganser (*Lophodytes cucullatus*; 32%), common merganser (*Mergus merganser*; 13%), red-breasted merganser (*M. serrator*; 0%), and ruddy duck (*Oxyura jamaicensis*; 1%).

Total ducks

The 2021 population estimate for all breeding ducks was **527,766 (95% CI = 387,346–708,325 individuals)**. This estimate was 6.8% higher compared to the previous year and is 20.4% 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 2021 population estimate for Canada geese was **179,384 (95% CI = 126,984–246,678 individuals)**. This estimate was 2.3% higher than the previous year’s modeled estimate and was 69.9% higher than the long-term, 35-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 2021, observers counted a total of 107 coots, one pair of whooping cranes, and 77 sandhill cranes (Figure 9). Excluding groups of five or more, 107 trumpeter swans were recorded and the 2021 population estimate (accounting for bird density and survey region area, but lacking VCF-correction) was **11,504 (95% CI = 4,893–22,295 individuals)**; Table 7; Figure 10).

Acknowledgments

We thank Larry Waskow for piloting the Cessna, and Patrice Eysers for serving as the second aerial observer. For ground surveys, we thank Kaleb Bolder, Eric Borchert, Michelle Carlisle, Nancy Christel, James Christopoulos, Jason Cotter, Steve Easterly, Austin Fischer, Alaina Gerrits, Dan Goltz, Matt Gross, Savanna Hartman, Bill Hirt, Jed Hopp, Derek Johnson, Tanner Klein, Carissa Knab, Morgan Kramschuster, Eric Kroening, Chad Mogen, Paul Napierala, Jacob Olson, Robert Roe, Paul Samerdyke, Aaron Seitz, Missy Sparrow-Lien, Josh Spiegel, Brandon Stefanski, Brendan Woodall, Brian Woodbury, and Cassandra Young. We would also like to thank Jes Rees Lohr for entering and proofing the survey data.

Literature cited

- Auger-Méthé, M., K. Newman, D. Cole, F. Empacher, R. Gryba, A. A. King, V. Leos-Barajas, J. Mills Flemming, A. Nielsen, G. Petris, and L. Thomas. 2021. A guide to state-space modeling of ecological time series. *Ecological Monographs* 91:e01470.
- Dooley, J. 2017. Canada goose derivations. US Fish and Wildlife Service unpublished memo.
- Kéry, M., and M. Schaub. 2012. Bayesian population analysis using WinBUGS: A hierarchical perspective. Academic Press, Waltham, MA, USA.
- March, J. R., G. F. Martz, and R. A. Hunt. 1973. Breeding duck populations and habitat in Wisconsin. Wisconsin Department of Natural Resources, Technical Bulletin No. 68, Madison, WI, USA.
- Platte, R. 1987. Standard operating procedure for aerial waterfowl breeding ground populations and habitat surveys in North America. US Fish and Wildlife Service and Canadian Wildlife Service, Ottawa, ON, CAN.
- Smith, G. W. 1995. A critical review of the aerial and ground surveys of breeding waterfowl in North America. U.S. Department of the Interior, National Biological Service Biological Science Report 5, Washington, D.C., USA.

Tables

Table 1: Type and number of wetlands per square mile observed during the last 10-year period, 2011–2021, SEC region.

Year	Wetland type							
	I, II, VI	III	IV, V	VII, VIII	Non-linear	Stream	Ditch	Linear
2011	2.5	0.7	3.8	1.0	8.1	2.0	2.2	4.2
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
% Change from previous year	-62.6%	-57.1%	7.5%	-23.0%	-37.1%	70.6%	-26.5%	1.5%
Long-term mean	3.9	0.9	3.0	1.1	8.9	1.7	2.5	4.2
% Change from long-term mean	-25.7%	-1.5%	68.7%	60.1%	18.9%	51.4%	12.3%	28.4%
10-Year mean (2011-2021)	4.0	1.0	3.5	1.3	9.8	1.8	2.8	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 2: Type and number of wetlands per square mile observed during the last 10-year period, 2011–2021, NHI region.

Year	Wetland type							
	I, II, VI	III	IV, V	VII, VIII	Non-linear	Stream	Ditch	Linear
2011	6.2	2.0	4.4	1.8	14.4	2.5	0.6	3.1
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
% Change from previous year	-41.9%	-57.1%	5.2%	212.2%	11.3%	15.9%	-17.5%	11.6%
Long-term mean	3.4	1.4	4.0	2.1	10.9	2.3	0.4	2.7
% Change from long-term mean	-59.4%	-18.7%	44.8%	150.8%	24.4%	41.7%	-23.4%	31.1%
10-Year mean (2011-2021)	3.3	1.6	4.4	2.1	11.4	2.5	0.5	3.0

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, 2011–2021, NLO region.

Year	Wetland type							
	I, II, VI	III	IV, V	VII, VIII	Non-linear	Stream	Ditch	Linear
2011	3.4	0.6	3.3	1.9	9.2	4.4	0.6	5.0
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
% Change from previous year	-46.0%	-31.1%	10.7%	149.2%	0.6%	24.5%	11.1%	21.4%
Long-term mean	4.1	0.8	2.2	2.1	9.2	3.5	0.8	4.3
% Change from long-term mean	-26.8%	44.0%	71.3%	126.8%	37.4%	41.4%	66.5%	46.1%
10-Year mean (2011-2021)	4.0	0.8	2.6	2.1	9.6	4.0	1.1	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 4: Type and number of wetlands per square mile observed during the last 10-year period, 2011–2021, SWD region.

Year	Wetland type							
	I, II, VI	III	IV, V	VII, VIII	Non-linear	Stream	Ditch	Linear
2011	1.1	0.2	1.8	0.6	3.7	3.1	0.5	3.6
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
% Change from previous year	-74.0%	-58.8%	11.0%	-77.0%	-49.8%	33.0%	-57.3%	7.5%
Long-term mean	1.4	0.3	1.5	0.3	3.5	3.1	0.7	3.8
% Change from long-term mean	-39.6%	29.8%	26.6%	-37.7%	-4.0%	53.2%	-9.4%	42.2%
10-Year mean (2011-2021)	1.6	0.4	1.6	0.4	4.1	3.4	0.9	4.3

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 5: Statewide and stratum-specific population estimates for the 2021 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	3.490	1.132	70,902	14,808
NHI	9,431	2.092	1.132	22,337	5,626
NLO	15,979	1.928	1.132	34,877	9,459
SWD	12,311	1.382	1.132	19,257	6,340
Subtotal				147,373	19,508
Blue-winged teal					
SEC	17,949	0.354	5.754	36,564	11,742
NHI	9,431	0.185	5.754	10,019	10,019
NLO	15,979	0.041	5.754	3,772	2,612
SWD	12,311	0.352	5.754	24,901	14,974
Subtotal				75,256	21,663
Wood duck					
SEC	17,949	0.975	6.614	115,713	26,759
NHI	9,431	0.492	6.614	30,709	8,439
NLO	15,979	0.533	6.614	56,366	15,887
SWD	12,311	0.461	6.614	37,505	16,575
Subtotal				240,293	36,255
Other duck species^a					
SEC	17,949	0.216	5.323	20,644	10,297
NHI	9,431	1.221	5.323	61,266	22,591
NLO	15,979	0.472	5.323	40,126	20,938
SWD	12,311	0.000	5.323	0	0
Subtotal				122,036	32,477
Canada goose					
SEC	17,949	2.906	1.817	94,790	16,742
NHI	9,431	1.456	1.817	24,964	8,228
NLO	15,979	1.015	1.817	29,488	10,152
SWD	12,311	0.933	1.817	20,883	6,539
Subtotal				170,125	22,222

^{*} 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 2021, aerial visibility correction factors for mallards, blue-winged teal, wood ducks, Canada geese, and "other ducks" were derived using 2, 13, 6, 2, and 13 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, 1973–2021.

Year	Mallard		Blue-winged teal		Wood ducks		Other ducks		Total ducks		Canada geese	
1973	106,956	102,926	185,361	210,097	6,636	9,555	113,753	87,515	412,706	406,735		
1974	94,322	101,671	254,440	213,094	15,442	15,018	70,978	66,818	435,182	406,664		
1975	120,460	104,766	237,426	205,522	26,520	21,702	42,472	49,405	426,878	392,037		
1976	109,862	100,623	200,649	188,857	26,164	23,542	42,851	40,419	379,526	363,095		
1977	91,657	92,970	195,737	169,877	21,475	22,107	14,411	29,584	323,280	330,375		
1978	61,646	85,565	134,205	146,711	17,811	21,370	57,686	40,846	271,348	301,965		
1979	78,600	90,925	120,892	129,639	31,697	27,561	34,541	37,308	265,730	290,523		
1980	116,488	103,757	69,404	117,243	29,261	27,957	32,920	35,923	248,073	289,690		
1981	142,831	111,046	258,054	127,130	40,817	28,809	63,336	38,185	505,038	315,864		
1982	89,472	105,125	98,641	104,940	9,524	15,850	21,081	23,928	218,718	260,606		
1983	119,462	108,610	60,465	88,521	10,642	16,373	11,727	16,811	202,296	238,314		
1984	104,759	106,028	64,951	83,289	28,294	26,364	11,991	15,088	209,995	235,320		
1985	73,909	103,257	84,199	83,498	25,757	32,762	8,929	14,513	192,794	240,979		
1986	110,763	116,139	51,266	80,466	82,747	62,065	17,237	19,336	262,013	276,501	11,129	12,723
1987	136,947	132,052	124,021	89,571	98,349	75,700	30,518	26,399	389,835	322,692	14,519	15,341
1988	148,901	146,550	67,580	87,678	54,260	61,573	16,333	28,789	287,074	334,667	15,339	18,799
1989	180,676	161,456	125,062	94,332	59,676	63,794	97,099	54,660	462,513	383,013	53,040	32,652
1990	151,356	167,433	70,169	90,834	67,065	69,648	40,040	55,204	328,630	389,237	22,840	26,303
1991	172,423	182,543	67,023	94,267	69,349	77,332	126,986	83,361	435,781	437,423	23,931	27,411
1992	249,727	205,613	179,125	110,899	145,118	106,523	109,834	78,960	683,804	500,330	34,668	33,157
1993	174,531	209,011	98,859	107,362	73,866	83,883	32,115	55,666	379,371	473,647	34,386	36,015
1994	283,400	234,773	144,041	109,404	63,078	81,247	80,710	68,480	571,229	514,993	36,125	40,567
1995	242,166	240,967	117,945	102,467	153,658	115,696	78,650	69,161	592,419	527,159	59,240	53,550
1996	314,413	249,406	69,960	90,445	76,475	95,028	75,457	62,485	536,305	507,847	55,888	59,483
1997	180,968	226,411	70,795	86,390	119,410	113,260	38,140	45,555	409,313	473,413	78,566	73,441
1998	186,891	229,927	75,975	86,982	121,713	119,294	28,219	38,208	412,798	476,091	74,712	80,264
1999	248,446	255,545	84,418	90,742	113,898	119,996	29,869	37,604	476,631	512,483	101,183	97,894
2000	453,979	289,634	117,338	95,335	141,882	133,321	31,191	41,965	744,390	574,372	129,508	114,221
2001	183,453	260,360	77,310	92,006	131,051	131,306	48,312	57,292	440,126	551,408	94,066	109,308
2002	378,542	284,499	66,033	93,510	135,129	130,368	161,087	92,527	740,791	602,933	118,476	128,535
2003	261,332	267,254	90,136	106,603	110,109	119,326	71,888	81,107	533,465	588,351	241,930	176,064
2004	229,175	255,080	213,755	131,232	114,550	120,719	94,014	84,432	651,494	609,799	149,003	149,939
2005	317,224	256,615	195,239	135,539	141,152	129,883	70,655	76,311	724,270	614,365	123,836	134,693
2006	219,494	232,597	108,701	123,591	121,650	119,983	72,726	74,193	522,571	560,068	134,683	134,348
2007	210,219	217,160	124,093	121,636	87,875	105,077	48,427	69,286	470,614	533,410	125,195	129,545
2008	188,429	205,799	179,549	120,029	126,440	119,226	132,506	90,143	626,924	542,639	116,715	128,981
2009	200,497	202,168	112,793	101,940	113,523	115,049	75,602	75,504	502,416	505,147	148,293	144,381
2010	199,107	197,782	50,188	84,452	103,769	112,591	32,757	61,806	385,821	471,212	157,622	154,559
2011	187,862	192,531	90,803	84,066	146,471	126,792	88,610	85,251	513,746	489,758	176,095	161,542
2012	196,950	189,668	105,791	80,694	106,626	109,362	111,712	105,194	521,079	491,925	145,386	148,254
2013	181,200	183,127	73,483	69,959	91,516	98,526	181,141	127,549	527,340	477,783	138,925	140,108
2014	158,747	176,512	34,337	58,774	104,140	98,470	97,875	103,834	395,099	437,058	126,299	132,503
2015	176,200	177,368	59,083	58,499	68,142	84,203	69,415	90,600	372,840	420,471	119,212	130,036
2016	164,147	177,426	37,936	56,173	89,775	93,960	98,640	96,501	390,498	426,798	129,562	137,340
2017	180,930	184,463	85,526	61,465	102,397	102,652	110,246	96,439	479,099	449,715	158,023	153,389
2018	216,652	192,708	45,130	58,630	100,055	106,602	77,560	82,520	439,397	452,933	157,950	160,170
2019	204,296	189,731	61,946	61,053	100,027	116,926	47,392	72,321	413,661	458,971	171,407	169,906
2020		181,070		63,440		157,347		90,780		494,046		175,267
2021	147,373	172,151	75,256	65,082	240,293	205,206	122,036	106,879	584,958	527,766	170,125	179,384
Mean (1973–2020)	182,989	178,930	111,486	105,185	81,383	82,619	64,886	61,995	440,743	436,559	102,287	103,448
Mean (2012–2021)	180,722	182,422	64,276	63,377	111,441	117,325	101,780	97,262	458,219	463,747	146,321	152,636
% change from previous year		-4.9%		2.6%		30.4%		17.7%		6.8%		2.3%
% change from 1973–2020	-19.5%	-3.8%	-32.5%	-38.1%	195.3%	148.4%	88.1%	72.4%	32.7%	20.9%	66.3%	73.4%

Table 7: Annual statewide estimates of breeding Trumpeter swan abundance in Wisconsin, 2010–2021. 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	1,205
2011	1,408	1,478
2012	1,999	1,908
2013	2,292	2,345
2014	2,979	2,956
2015	3,679	3,666
2016	5,029	4,581
2017	4,833	5,142
2018	5,677	6,078
2019	6,106	7,195
2020		9,750
2021	11,197	11,504

Figures

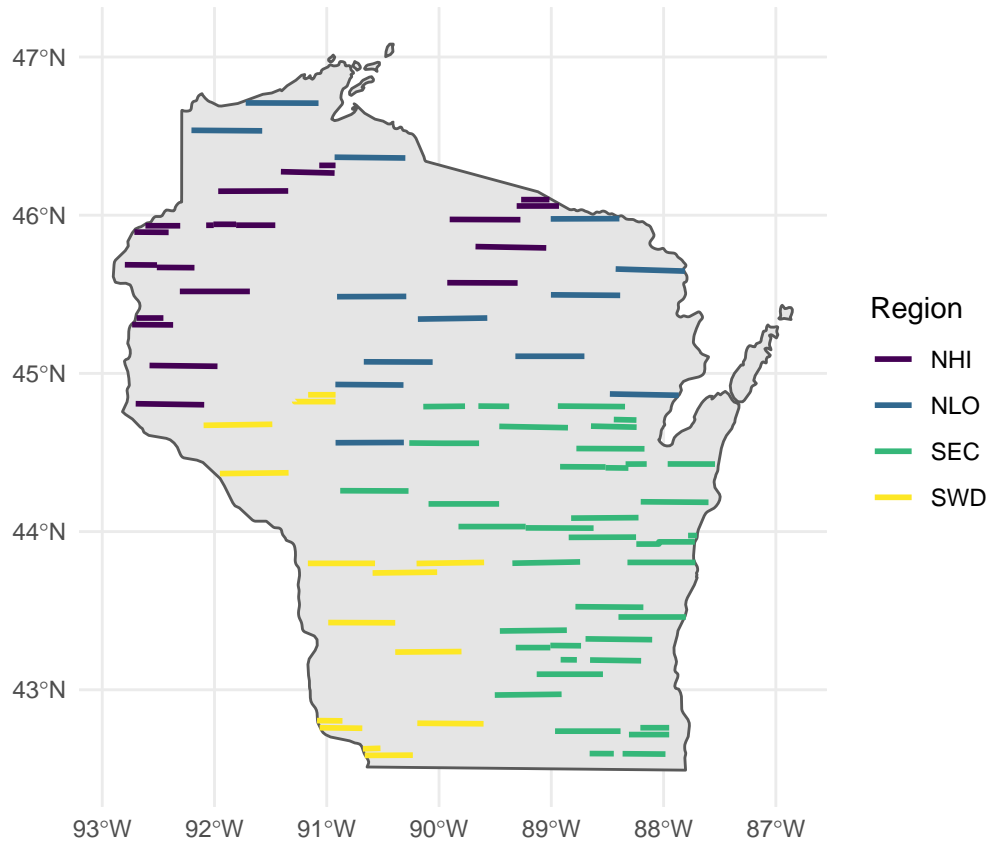


Figure 1: Wisconsin Waterfowl Breeding Population Survey aerial transects ($n = 66$) labeled by survey region. The four regions surveyed are the Northern High Density region (NHI), Northern Low Density region (NLO), Southeast Central region (SEC), and Southwest Driftless region (SWD).

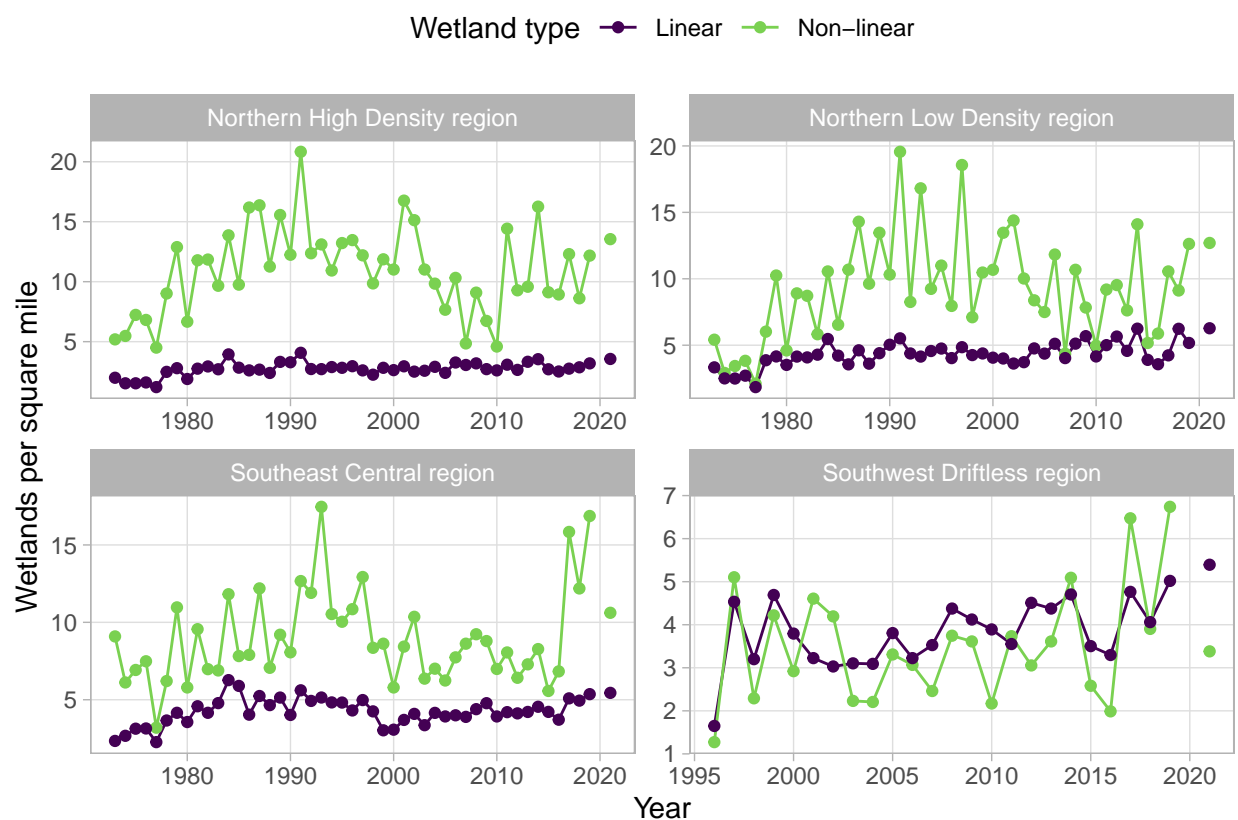


Figure 2: Annual variability in total linear and non-linear wetlands per square mile by survey region. Note that surveys were not conducted in 2020 due to the COVID-19 pandemic.

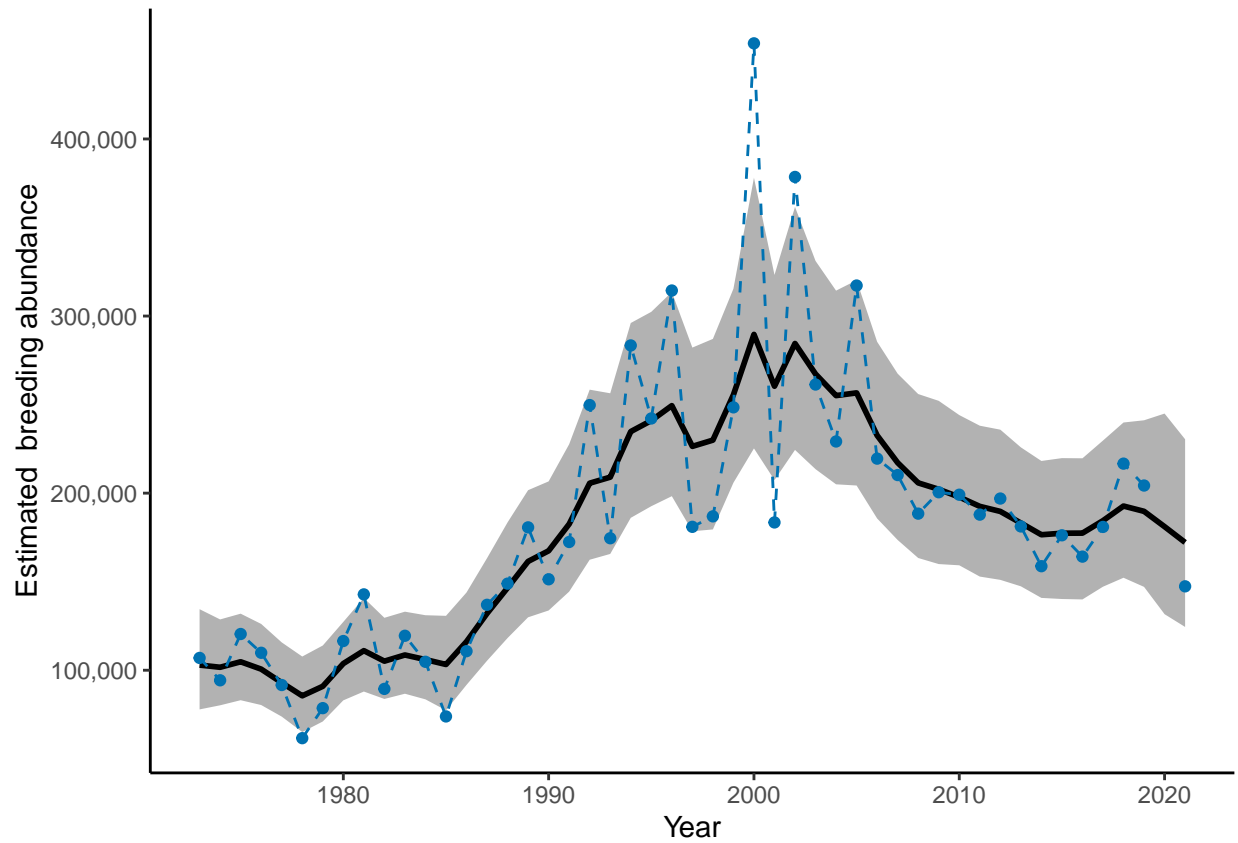


Figure 3: Annual statewide estimates of breeding mallard population size in Wisconsin, 1973–2021. Black line and gray shaded region are the mean and 95% credible interval estimates for the state-space population trend, and blue points and dashed line show the annual survey counts. Note that surveys were not conducted in 2020 due to the COVID-19 pandemic.

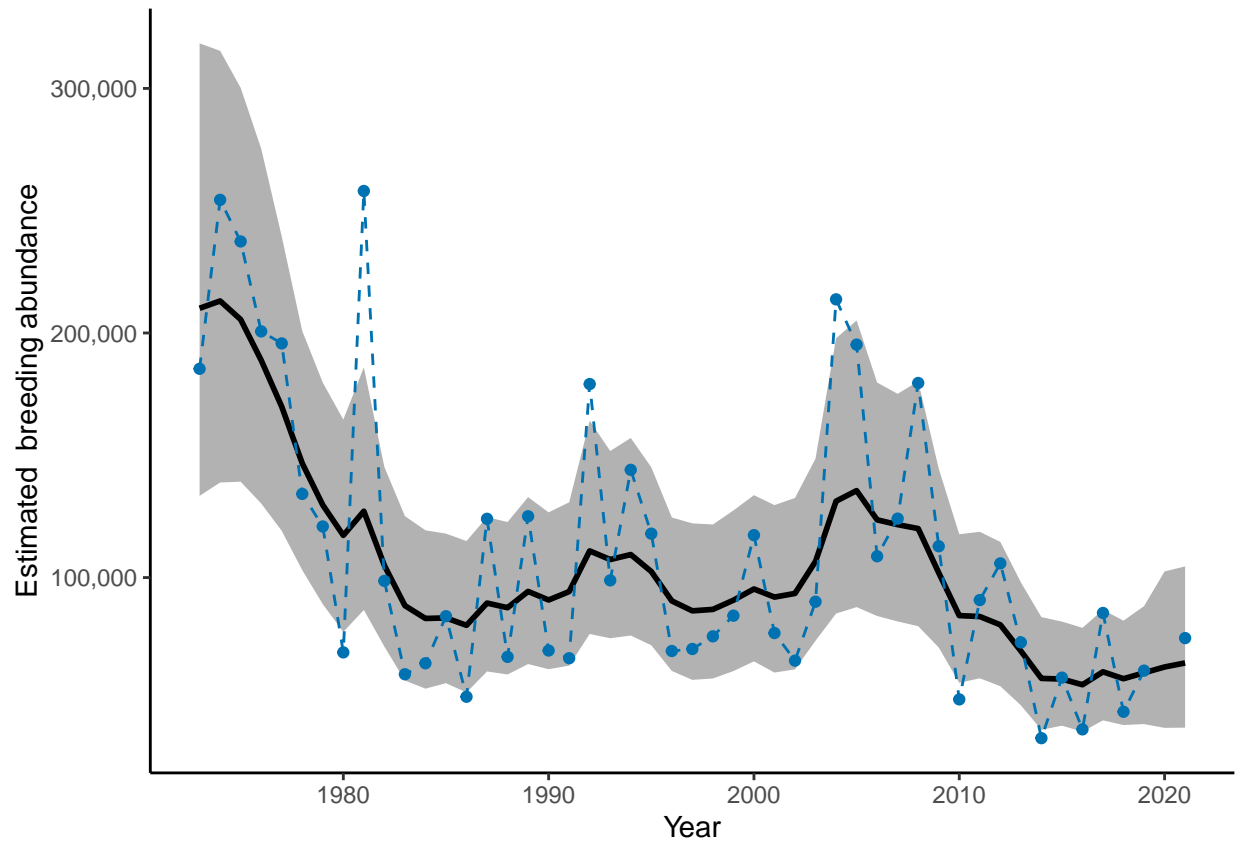


Figure 4: Annual statewide estimates of breeding blue-winged teal abundance in Wisconsin, 1973–2021. Black line and gray shaded region are the mean and 95% credible interval estimates for the state-space population trend, and blue points and dashed line show the annual survey counts. Note that surveys were not conducted in 2020 due to the COVID-19 pandemic.

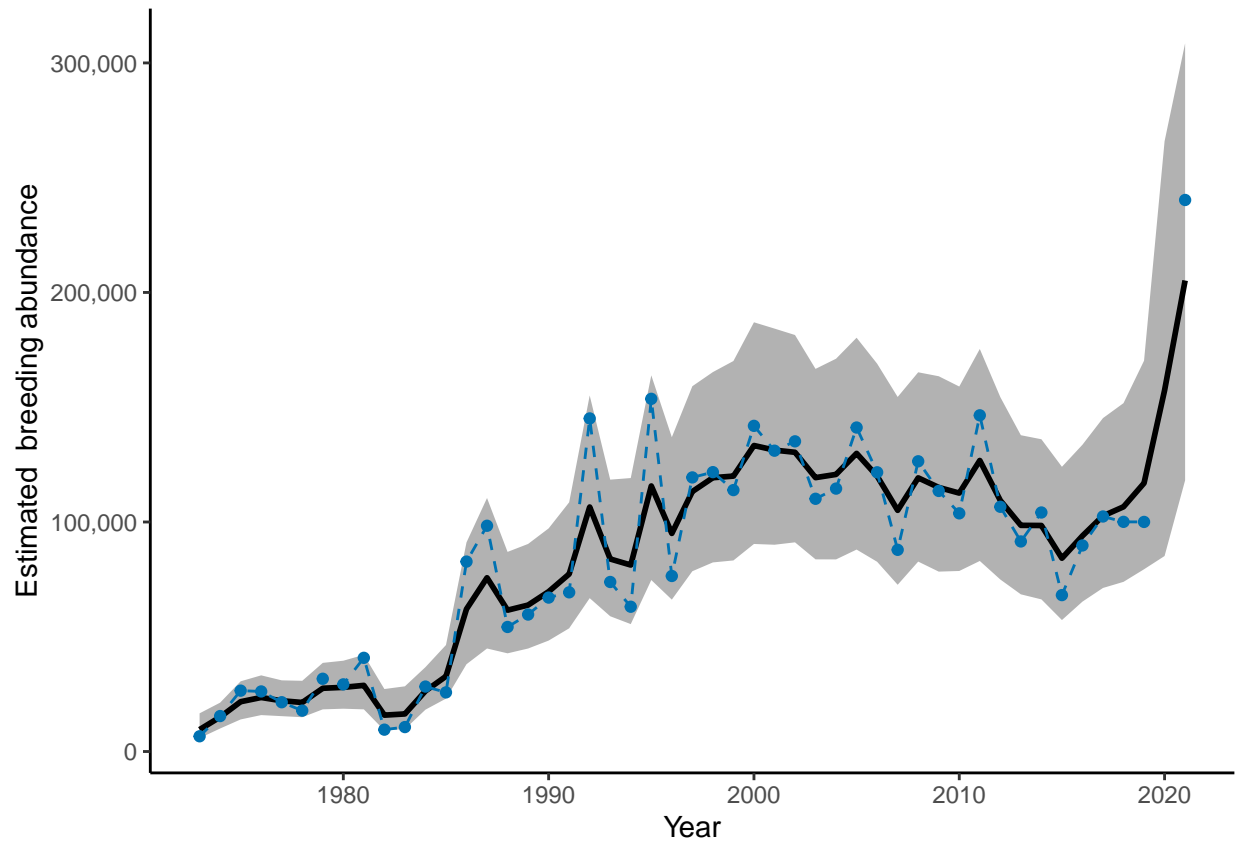


Figure 5: Annual statewide estimates of breeding wood duck abundance in Wisconsin, 1973–2021. Black line and gray shaded region are the mean and 95% credible interval estimates for the state-space population trend, and blue points and dashed line show the annual survey counts. Note that surveys were not conducted in 2020 due to the COVID-19 pandemic.

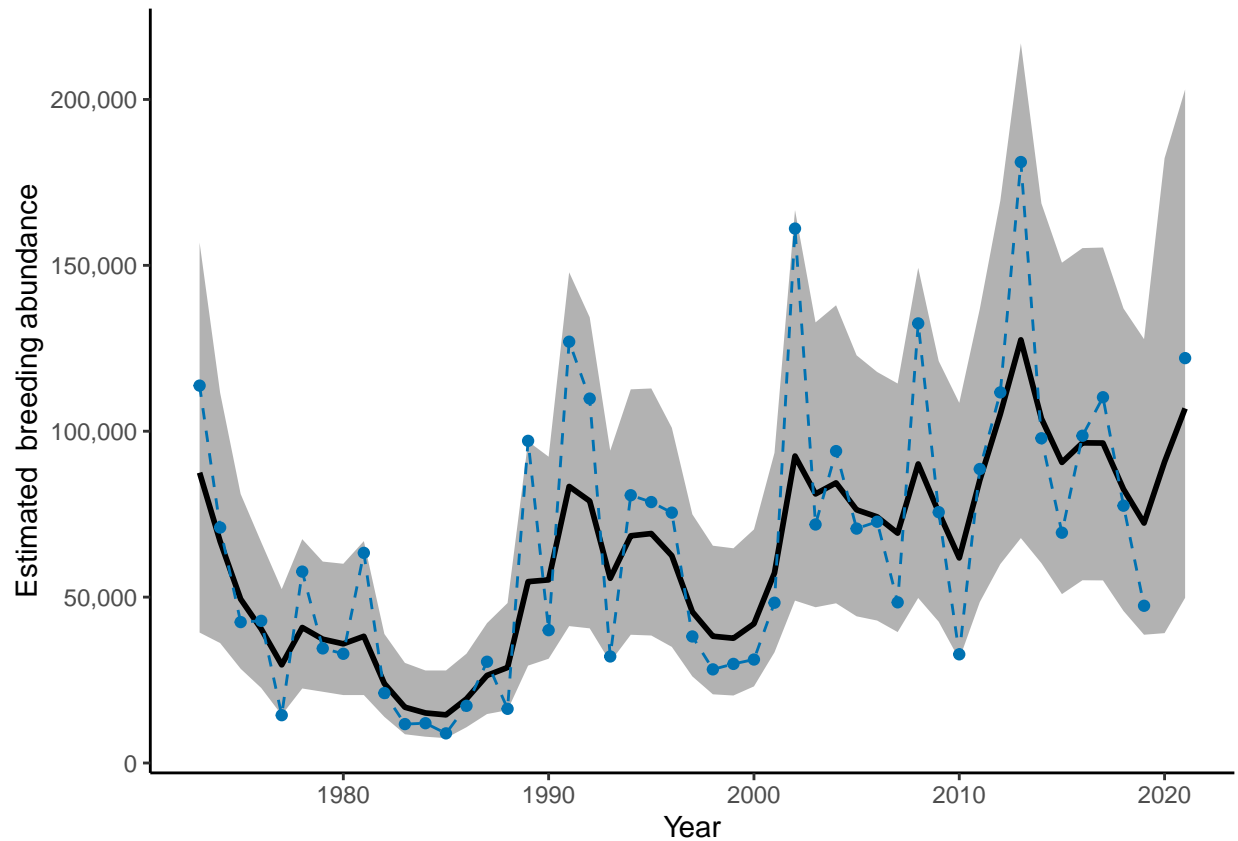


Figure 6: Annual statewide estimates of breeding ‘other duck’ abundance in Wisconsin, 1973–2021. Black line and gray shaded region are the mean and 95% credible interval estimates for the state-space population trend, and blue points and dashed line show the annual survey counts. Note that surveys were not conducted in 2020 due to the COVID-19 pandemic.

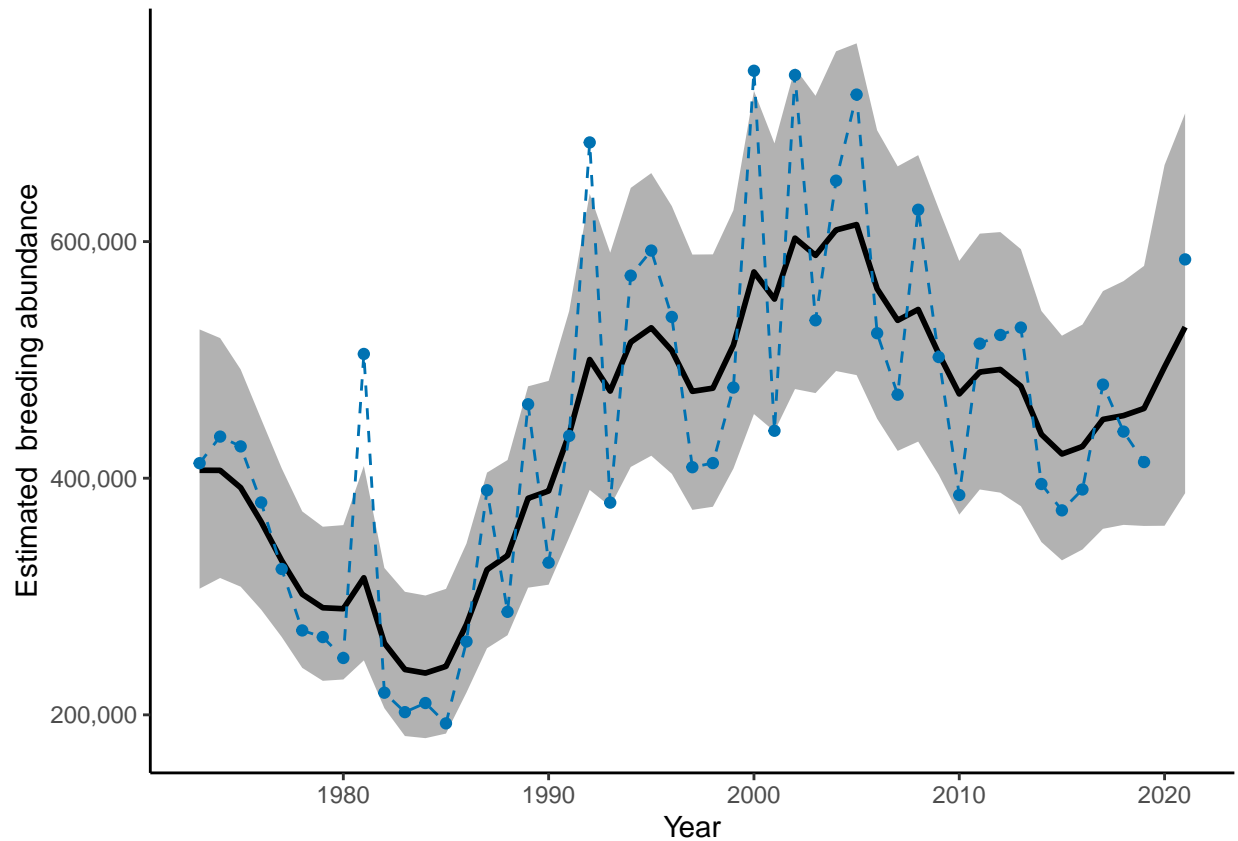


Figure 7: Annual statewide estimates of total breeding duck abundance in Wisconsin, 1973–2021. Black line and gray shaded region are the mean and 95% credible interval estimates for the state-space population trend, and blue points and dashed line show the annual survey counts. Note that surveys were not conducted in 2020 due to the COVID-19 pandemic.

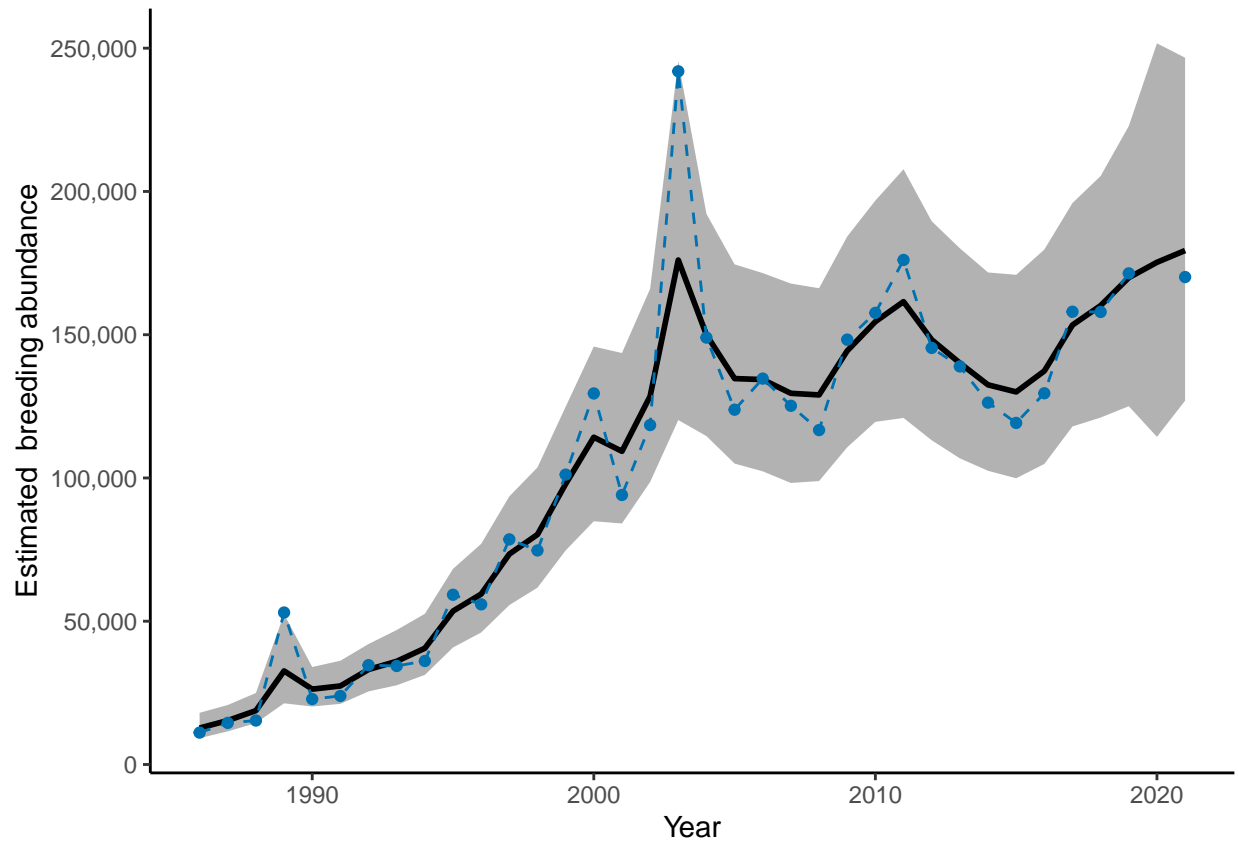


Figure 8: Annual statewide estimates of breeding Canada goose abundance in Wisconsin, 1986–2021. Black line and gray shaded region are the mean and 95% credible interval estimates for the state-space population trend, and blue points and dashed line show the annual survey counts. Note that surveys were not conducted in 2020 due to the COVID-19 pandemic.

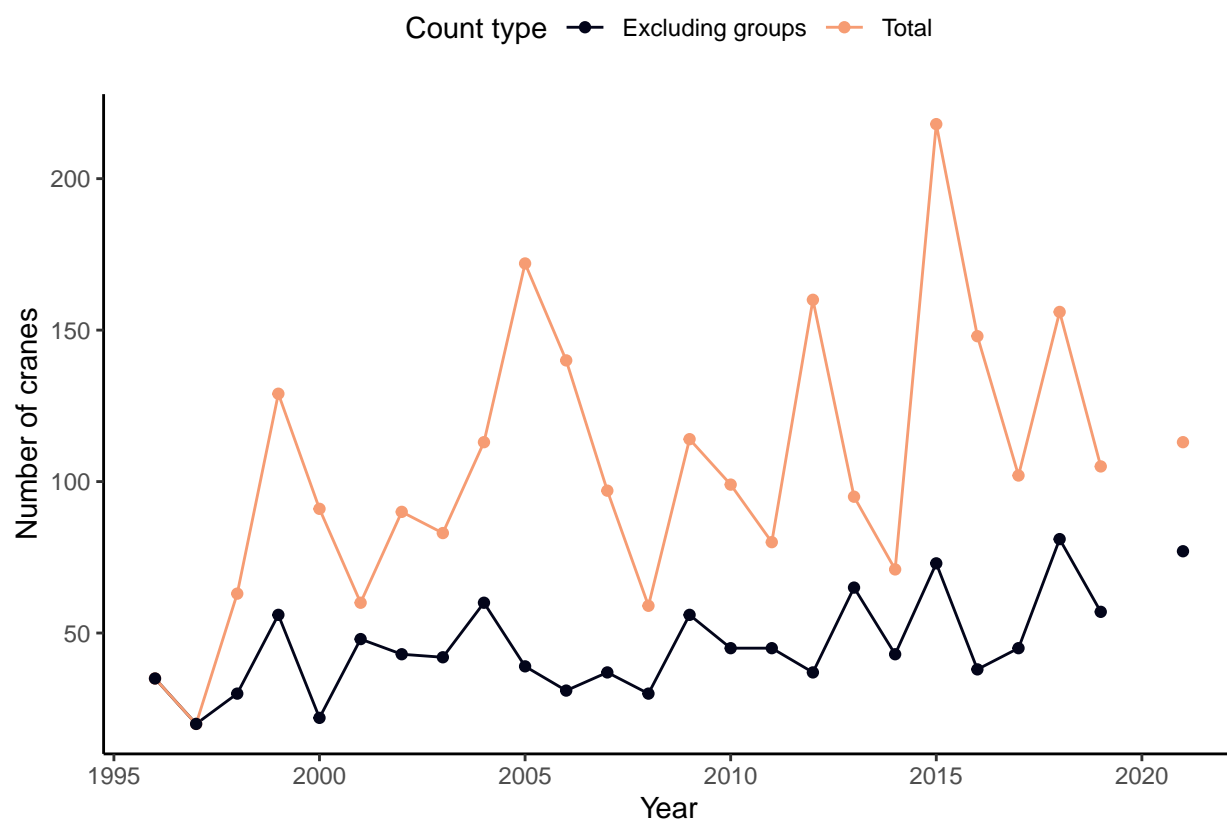


Figure 9: Annual counts of sandhill cranes (raw estimates) observed from the air during the Waterfowl Breeding Population Survey, 1996–2021. Note that surveys were not conducted in 2020 due to the COVID-19 pandemic.

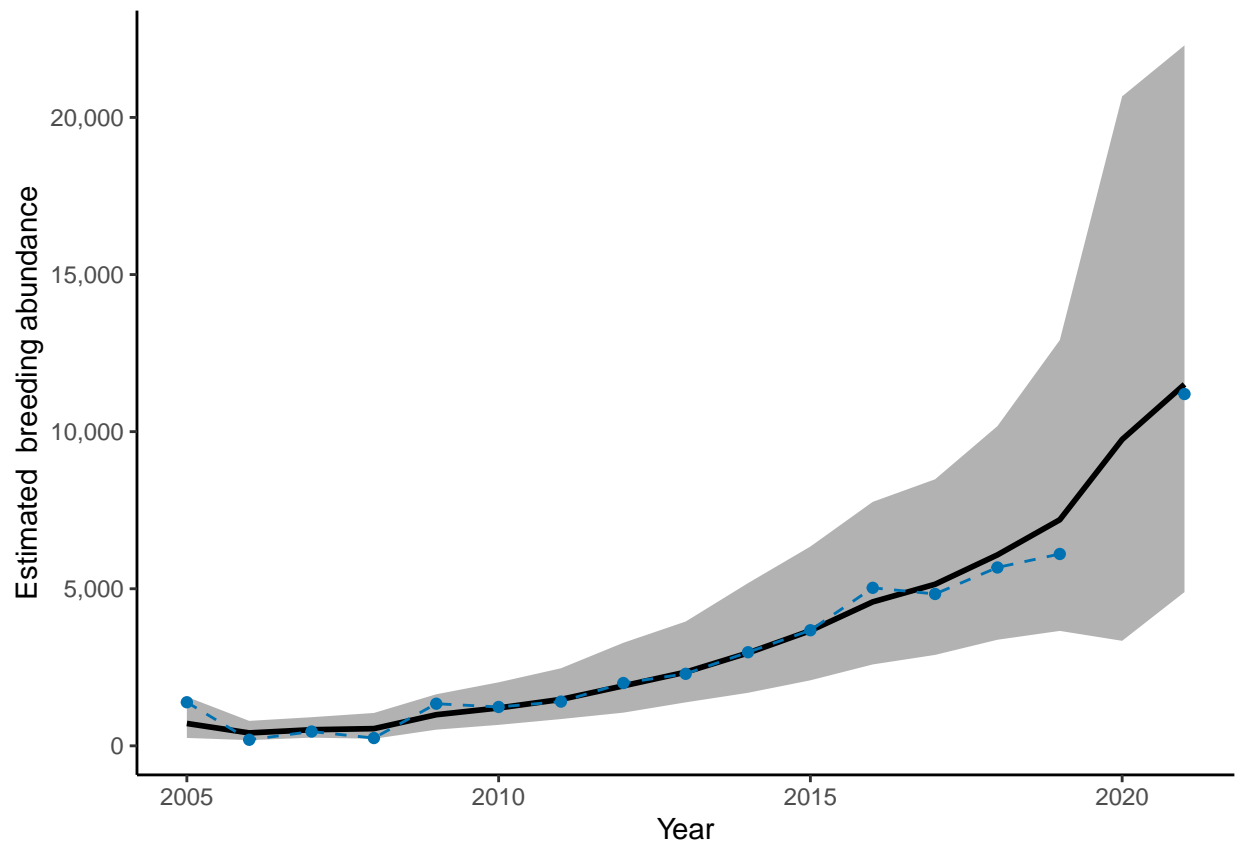


Figure 10: Annual statewide estimates of trumpeter swan abundance in Wisconsin, 2005–2021. Black line and gray shaded region are the mean and 95% credible interval estimates for the state-space population trend, and blue points and dashed line show the annual survey counts. Note that surveys were not conducted in 2020 due to the COVID-19 pandemic.