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National Wildlife Refuge System



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Midwinter Aerial Waterfowl Surveys on National Wildlife Refuges in the Southeast, 2026

Version 1.1 (PUBLIC RELEASE)



Cover Photograph: Pintails and Canvasbacks at Catahoula National Wildlife Refuge in January 2026 during an aerial survey flight. Credit. J. Marty.

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Overview

National Wildlife Refuges (NWR) in the Southeast (Region 4) have objectives to provide habitat resources for approximately 6.5 million waterfowl during the non-breeding season (Hagy et al. 2022b). Although many NWRs in the Southeast conduct some form of waterfowl monitoring (e.g., abundance, habitat, harvest), there has traditionally been no standard protocol or regionally coordinated effort to ensure statistically robust surveys for waterfowl to address local and regional information needs. For example, nearly three quarters of NWRs in the Lower Mississippi Valley ecoregion have an emphasis on waterfowl management and most conduct some form of waterfowl monitoring; however, there is currently limited survey coordination, use of written protocols, data sharing among NWRs, or analysis and reporting which drives future management decisions (Richardson et al 2014). Coordinated monitoring following best practices (i.e., Inventory and Monitoring Plans) enhance strategic resource allocation, facilitate adaptive resource management, and significantly increase the scientific basis of waterfowl management activities as required by Fish and Wildlife Service (FWS or Service) policy (Hagy et al. 2021).

Waterfowl abundances are used by the NWR system to assess performance relative to NWR purposes and objectives, to assess the outcomes of management practices, and for public outreach. Moreover, recent planning efforts within the NWR System have incentivized accurate estimates of total waterfowl population size and created a need for improved and coordinated waterfowl surveys among NWRs (Hagy et al. 2021, 2022a). The lack of a coordinated survey with a robust design and clear objectives limits usefulness of existing data and underscores the importance of implementing a coordinated waterfowl survey to address current information needs. Erosion of the Midwinter Waterfowl Survey due to criticisms on the lack of experimental design



Figure 1. Coastal marsh habitat on Sabine National Wildlife Refuge in January 2026. Credit B. Fortier.

and implementation challenges provided an opportunity to test a model for replacement that combines sound experimental design with cost efficiency (Heusmann 1999, Sharp et al. 2002). Several southeastern state agencies (e.g., Mississippi Department of Wildlife, Fisheries, and Parks [MDWFP 2026]; Arkansas Game and Fish Commission [AGFC 2026], Louisiana Department of Wildlife and Fisheries [LDWF 2026]) have implemented large-scale probability-based waterfowl surveys (e.g., transect based), but inclusion of NWRs is sporadic and landscape-scale designs are inappropriate for estimating abundances on smaller, discrete areas, such as NWRs.

Several methods have been recommended to address science and administrative needs for waterfowl monitoring data using cost-efficient approaches and incorporating citizen science (Soulliere et al. 2013). Although ground surveys are currently common and can be a useful method for estimating waterfowl density and abundance on small, individual units, many NWRs have areas that are difficult to access and cannot overcome logistical difficulties posed by ground surveys to estimate total abundance. Additionally, use of ground counts through the Integrated Waterbird Monitoring and Management (IWMM) protocol are insufficient or impractical to generate unbiased estimates of total waterfowl abundance at most NWRs due to logistical challenges associated with the remote nature of many locations used by waterfowl within NWRs (Fig. 1; Rice and Hagy 2020). Alternatively, aerial surveys are logistically efficient, cost-effective, and scientifically valid for estimating waterfowl abundance on NWRs (Gilbert et al. 2021). For example, using a single point-in-time survey (i.e., midwinter waterfowl survey) and available migration curves (e.g., eBird, IWMM) to generate annual use days is an extremely cost-efficient and valuable technique for NWRs (Hagy 2020).

The goal of this project is to demonstrate the coordination of survey efforts across multiple NWRs supporting migrating and wintering waterfowl to address local and regional data needs and help quantify the conservation footprint of the NWR System for waterfowl in the Southeast. Specifically, our objective was to estimate waterfowl abundance by species on individual units of NWRs in the Southeast across many habitat resource types (e.g., emergent wetland, open water, forested, harvested agriculture, standing agriculture, mixed). Waterfowl population estimates are used by local and regional NWR staff to assess performance relative to NWR purposes and objectives, for essential administrative planning purposes, and for public outreach.

Methods

Aerial Surveys

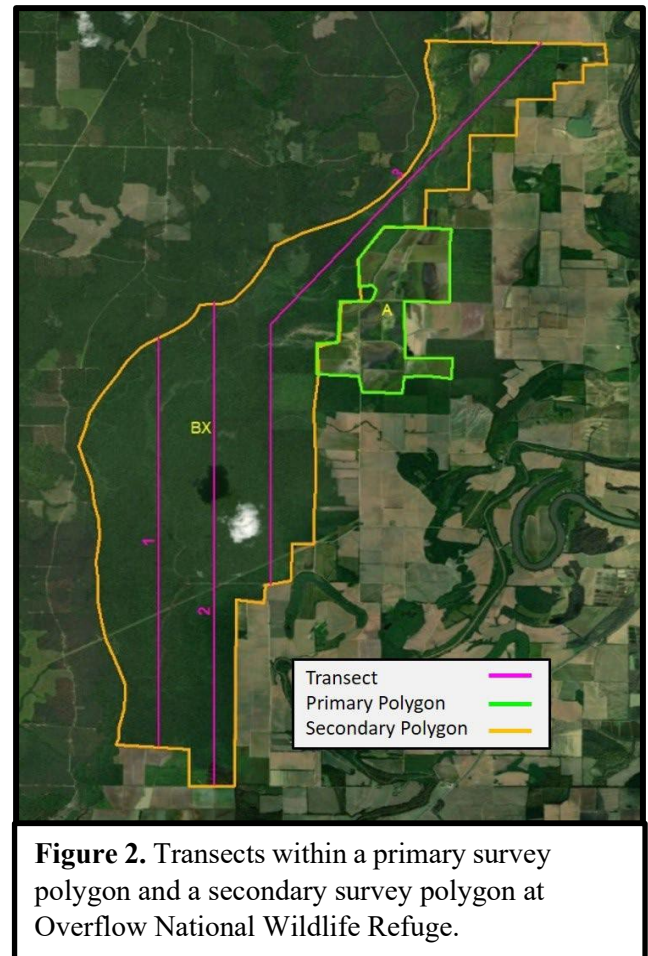


Figure 2. Transects within a primary survey polygon and a secondary survey polygon at Overflow National Wildlife Refuge.

We flew aerial surveys on 61 NWRs in Alabama, Arkansas, Florida, Louisiana, Mississippi, North Carolina, South Carolina, and Tennessee, during 1–17 January 2026. Surveys were conducted using a Cessna 206 (Pilots – G. Wilkerson; Observers – J. Marty) in Arkansas, Mississippi, Louisiana, and Tennessee; Quest Kodiak 100s (Pilots – J. Rayfield, G. Wilkerson, S. Yates; Observers - B. Fortier, C. Bleke, B. Van Druten, N. Wirwa) in Alabama, Florida, Louisiana, North Carolina, and South Carolina. Refuge natural wetlands and managed areas (e.g., moist-soil impoundments and agricultural fields) that were potentially occupied by waterfowl were designated as primary (i.e., high density strata) or secondary (i.e., unknown or low-density strata) survey units based on size, logistical considerations, anticipated continuousness of waterfowl distribution, and anticipated abundance (Howard et al. 2024).

Primary survey units (i.e., primary polygons) are generally small and discrete areas where large groups of waterfowl congregate at high densities (e.g., groups of impoundments, agricultural fields with standing crops, small lakes and ponds; Fig. 2). For specific sites of interest and small areas where distribution of ducks is non-random (e.g., NWRs), transects and other randomized designs are typically inefficient, often inappropriate, and costly. However, census-style surveys used to conduct complete surveys of specific locations can be used to cost-effectively and accurately estimate waterfowl abundance in those areas (Gilbert et al. 2021). Within each primary survey unit, observers conducted a complete count using a census-style method to visually estimate total population size and species composition (Stafford et al. 2007, 2010).

Secondary survey strata are typically large areas with unknown or low-density distribution of waterfowl (e.g., large lakes, bays, floodplain forests, rivers; Fig. 2). Within each secondary survey strata unit, observers counted waterfowl along transects that spanned each unit. Transects were randomly assigned to a location with respect to prior knowledge of waterfowl distribution and flooding conditions at the time of the survey. A transect location was assigned within 500–1000 meters of one side of a survey unit and



Figure 3. Observations of waterfowl or other waterbirds along transects at Pea Island and Lacassine NWRs.

subsequent transects were allocated at approximate equal intervals (randomly 500–1500 meters) throughout the rest of the survey unit. Transect locations were chosen to provide representative coverage across any known elevation gradients or habitat conditions within a systematic-random framework.

Observers recorded the number of waterfowl present by species in each habitat resource type (Fig. 3). Observations were recorded using a proprietary voice recording system developed for the Service. We included unknown species in our estimate of dabbling ducks for summary purposes, as most encounters belonged to this guild. All surveys were conducted at approximately 200 feet (range 150–250 feet) above ground level (AGL) to minimize waterfowl disturbance, minimize risk to aircrews, and allow suitable species identification. Observations were recorded within a 200-meter survey viewing area (approximately 30–230-meter lateral) from the aircraft in open cover types (e.g., open water, emergent vegetation, mudflats) and restricted to 100 meters in forested cover types based on best professional judgement. Some transects included only data from the primary observer seated in the front passenger seat of the aircraft, while some transects had a secondary observer available and provided concurrent data from the pilot-side, rear seat of the aircraft. All observers had experience conducting aerial bird surveys and practiced using USFWS aerial observer training software (USFWS 2026).

Analysis

We estimated abundance within both primary and secondary survey units using a two-step visibility bias correction process to account for detection probability and count bias (Pearse et al. 2008). Visibility bias is the difference between the number of individual present in a survey area and the number of individuals counted in the same survey area. Detection probability is the probability that an observer will detect an individual or group of individuals given they are present in the survey area (Pearse et al. 2008b). Inaccurate counts or count bias arise from incorrectly estimating the number of individuals present or incorrectly identifying individuals to species given at least one individual is present and detected (Pearse et al. 2008b).

First, counts were multiplied by the reciprocal of a visibility estimate from the aircraft assigned by the primary observer (10–100%) to account for approximate detection probability (Pearse et al. 2008b; Fig. 4). These visual estimates represented the proportion of the transect or polygon survey area (i.e., water surface) that was viewable and not obstructed by canopy coverage, emergent vegetation, or other obstructions. Gilbert et al. (2021) determined that detection probability approximated 1.0 for census-style surveys of primarily open-water areas in the Illinois River Valley during autumn migration. Pearse et al. (2008b) found that detection probability varied by waterfowl group size and habitat resource type along transects conducted in the lower Mississippi Alluvial Valley. However, they determined that detection probability approached 1.0 when group size exceed 30 individuals in open cover types, which was almost always the case in primary polygons (Pearse et al. 2008b). Although Pearse et al. (2008b) showed that detection

probability was more dramatically affected by group size in forested wetlands, their surveys were conducted from ~500 feet AGL and those results likely differ from our surveys conducted from ~200 feet AGL due to increased detection probability at the lower altitude. Thus, we used a hybrid approach based on perceived visibility of the primary observer that resulted in correction within the range found by Pearse et al. (2008*a,b*). This approach assumes that if visibility (i.e., lack of physical obstructions) was not obstructed by emergent vegetation or tree canopy (visibility = 100%) then detection probability approximated 1.0 following Gilbert et al. (2021).

Secondly, detection-corrected estimates were adjusted for count bias using published correction factors (Table 1). Survey methodology and logistical issues did not allow visibility bias to be estimated using double observer or distance methods during the survey itself. If available, we used species-specific correction factors. If these produced unreasonable results or were unavailable, we substituted guild-specific correction factors from Gilbert et al. (2021), assuming that would be the conservative approach.

We estimated waterfowl abundance for secondary survey units by summing visibility-corrected estimates by transect, converting these abundances to densities using the survey area for each transect (Table 2), and extrapolating density estimates for each transect to the total area of the secondary polygon. We weighted total abundance estimates for each secondary polygon by transect length by multiplying the transect length by the total waterfowl abundance, summing these products within each secondary survey unit, and dividing the total by the number of transects. Weighting estimates by transect length ensured that short transects did not have the same effect on estimates as longer transects that covered more area of the polygon. Prior to weighting, transect area surveyed was adjusted using visual estimates of proportional flooding.

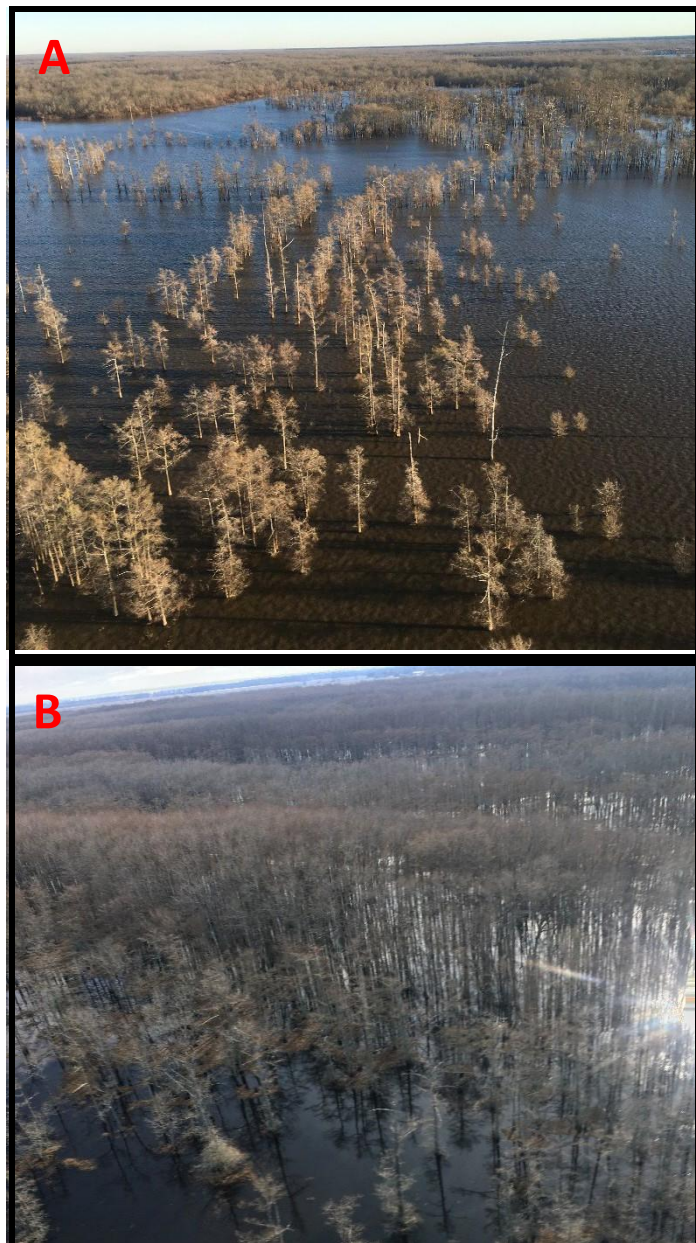


Figure 4. Forested wetlands at Matthews Brake (A; ~80% visibility) and Big Lake (B; ~50% visibility) National Wildlife Refuges during January 2020.

We estimated total use days from aerial surveys using migration curves from Hagy et al. (2022b) following the rationale of Soulliere et al. (2013). Hagy et al. (2022b) used eBird to build migration curves for all NWRs in the Southeast and then refined those curves using local NWR data and best professional opinion from local NWR staff. These “standard” curves represented average proportional abundance relative to peak migration of waterfowl by guild through the NWR. We adjusted abundance estimates by multiplying the reciprocal of the proportion of abundance relative to the peak from each curve anchored on 15 January, which was the approximate mid-point of the surveys (see Fig. 4 in Soulliere et al. 2013). For example, if a migration curve showed that the typical peak abundance at a NWR occurred in November and abundance was 70% of the peak in mid-January, the estimate was adjusted proportionally upward to account for this difference.

Variances were not calculated for primary or secondary polygon estimates because of the complexity of doing so at this time. Several sources of uncertainty existed at different steps in the estimation process, and variances were available for some of the model parameters but not all. More explicitly, both visibility bias components (i.e., detection probability and count bias) have associated variances, although the variance associated with detection probability used in our model was unknown and practically inestimable. Additionally, secondary polygons had a sufficient number of transects to estimate variances around estimates, but the transect weighting process would have affected how variances were applied to overall estimates, which was not a straightforward process. Similarly, use-day estimates resulting from the migration curve would also have required estimates of variance from multiple sources, including the migration curves themselves. Thus, estimating variances around final estimates would have required a complex simulation process that we have not completed at this time. In the future, we hope to include variance estimates, as they would be valuable to help refine the study design (e.g., optimal transect allocation).

Results

General

We used FWS Migratory Bird Survey Branch (MBSB) aircraft to survey 2–8 NWR/day around the typical Midwinter Waterfowl Survey period in early January. Five observers participated in the surveys on NWR units (*n*), including J. Marty (38), B. Van Druten (12), C. Bleke (10), B. Fortier (10), N. Wirwa (1). The proportion of raw observations included in the final estimates varied across observers (%) on NWR units, including J. Marty (55), B. Van Druten (14), C. Bleke (14), B. Fortier (14), N. Wirwa (3).

Habitats surveyed were categorized as mixed (37%), followed by perennial emergent (26%), forested wetlands (11%), open water (12%), seasonal emergent (9%), harvested crops (4%) and other cover types (1%). Observer-estimated visibility for detection probability was least in forested cover types (65%), followed by mixed (84%), perennial emergent (93%), unharvested crop (98%), seasonal emergent (99%), open water (99%), harvested crop (100%), and open emergent (100%) cover types. Proportional flooding was least in forested (12%) and mixed (38%) units, followed by open emergent (45%), unharvested crop fields (50%), harvested crop (55%), seasonal emergent (59%), perennial emergent (76%), and open water (98%) cover types.

Surveys included 296 polygons, with 175 primary and 121 secondary units. Primary polygons (census-style surveys) accounted for 35% of estimated waterfowl abundance and secondary polygons (transect-style surveys) accounted for 65% of waterfowl abundance estimates. However, this balance varied among taxa with secondary polygons accounting for 62% of dabbling duck, 68% of diving duck, 68% of geese, 74% of swan, and 61% of crane estimates.

Abundance

Approximately 2.3 million waterfowl were estimated on NWRs surveyed following visibility-bias correction and extrapolation (Table 3), including 1,139,978 dabbling ducks, 712,105 diving ducks, 377,126 geese, 38,060 swans, and 19,823 cranes. Observers also counted 69,003 American coot (*Fulica americana*) and 102 bald eagles (*Haliaeetus leucocephalus*).

Dabbling ducks comprised the majority of estimates at 50%, followed by diving ducks (31%), geese (16%), swans (2%), and cranes (1%). Pintail (*Anas acuta*, 30%), gadwall (*Mareca strepera*, 25%), mallard (*Anas platyrhynchos*, 17%), teal (combined green-winged teal [*Anas carolinensis*] and blue-winged teal [*Spatula discors*]; 13%), and American wigeon (*Mareca americana* [10%]), comprised most dabbling ducks. Dabbling duck estimates decreased 12% from 2025 to 2026.

Redhead (*Aythya americana*; 27%), Ring-necked ducks (*Aythya collaris*; 25%), scaup (combined lesser scaup [*Aythya affinis*] and greater scaup [*A. marila*]; 24%), canvasback (*Aythya valisineria*; 17%), and bufflehead (*Bucephala albeola*; 7%) comprised the majority of diving ducks. Light geese (combined lesser snow [*Anser caerulescens*], greater snow [*A. caerulescens*], and Ross's geese [*A. rossii*]; 86%) and greater white-fronted geese (*Anser albifrons*; 8%) comprised the majority of geese. Diving duck (16%), geese (25%), swan (39%), and crane (63%) abundance increased from 2025 to 2026.

The greatest waterfowl estimates were from Delta NWR (414,855), Mattamuskeet NWR (286,972), Sabine NWR (219,052), Catahoula Lake (211,878), Lacassine NWR (183,614), Breton NWR (90,204), Pocosin Lakes NWR (74,070), and Wheeler NWR (71,901). Collectively, abundance estimates on NWRs surveyed in 2026 remained similar to those in 2025 (1% increase) for total waterfowl. Eight NWRs met or exceeded their NWR abundance objectives, including Breton, St. Marks, Pea Island, Catahoula Lake, Delta, Lacassine, Sabine, and Mattamuskeet NWRs.

Peak abundance estimated from migration curves ranged from 0 to 506,587 waterfowl across all surveyed NWRs, with an average peak abundance of 49,019 waterfowl/NWR (Table 4). The migration curve model increased peak abundance by an average of 8% for dabbling ducks, 17% of diving ducks, 41% for geese, 4% for cranes, and 56% for swans across NWRs.

Comparison with State Surveys

The Mississippi Department of Wildlife, Fisheries, and Parks (MDWFP 2026); Arkansas Game and Fish Commission (AGFC 2026); and Louisiana Department of Wildlife and Fisheries (LDWF 2026) conduct probability-based aerial waterfowl surveys in portions of Arkansas, Louisiana, and Mississippi during the traditional midwinter survey period. Estimates of total duck abundance on NWRs was 25.7% of regional abundance in the four survey regions (Fig. 9). Collectively, partners estimated 3.6 million ducks and geese in these regions during early January survey period.

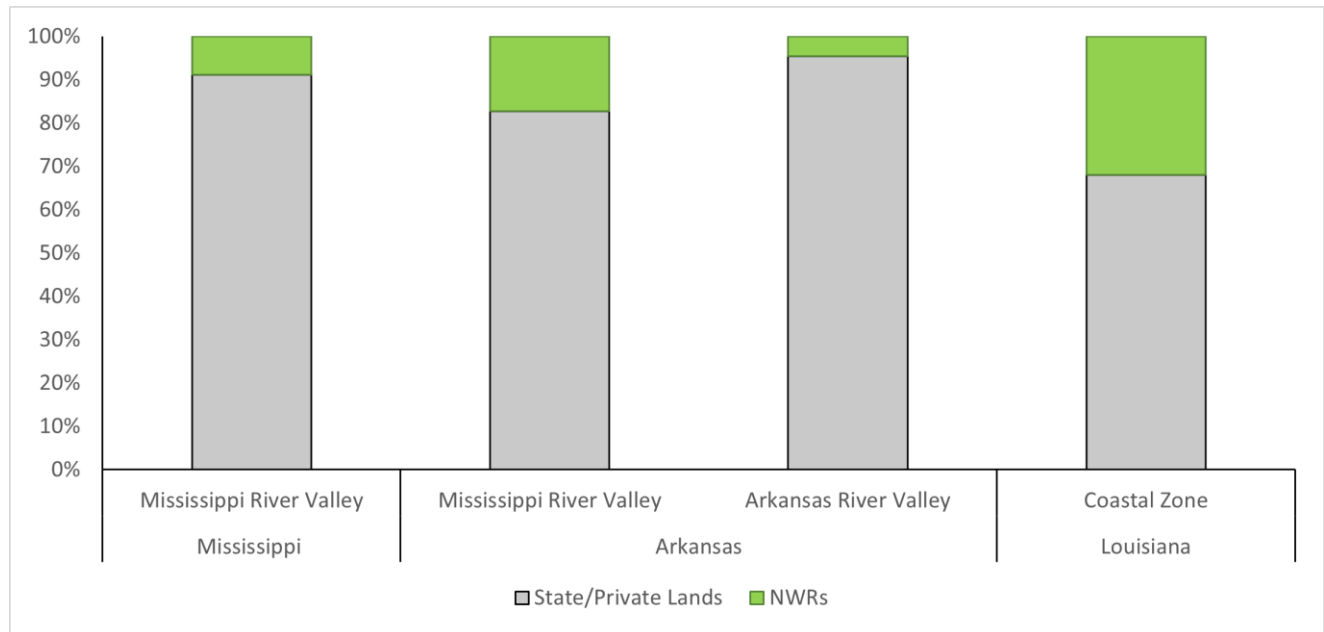


Figure 9. Proportion of total ducks observed on NWRs relative to those observed on state and private lands through state-coordinated aerial waterfowl surveys in regions of Arkansas, Louisiana, and Mississippi during early January 2026.

Use Days

Total estimated use days from aerial surveys across all NWRs were greatest for dabbling ducks (91.5 million), followed by diving ducks (53.2 million), geese (23.3 million), swans (4.7 million), and cranes (1 million; Table 5). Across taxa, predicted use equated to approximately 244 million waterfowl energy days. Collectively, waterfowl energy-day estimates on NWRs surveyed in 2026 were 97% below overall waterfowl objectives, 264% below dabbling duck objectives, 56% below diving duck objectives, and 18 below crane objectives. In contrast, estimates were 12% above objectives for geese and 66% above for swans.

Raw data, unit-level data, and spatial data can be found here:

<https://iris.fws.gov/APPS/ServCat/DownloadFile/272611>

Discussion

Aerial surveys are an efficient and effective survey method for estimating total waterfowl abundance on NWRs in the Southeast. These NWR-scale estimates are important for NWRs to communicate their importance to assess their performance relative to objectives within an adaptive resource management framework, quantify contributions to the North American Waterfowl Management Plan, advance waterfowl science and management, and to the public (Hagy et al. 2021, 2022). Despite estimating abundance on 6 more NWRs in 2026 than in 2025, and total estimated waterfowl abundance across the region remained similar from 2025 to 2026 (Marty et al. 2024). Environmental conditions likely influenced latitudinal distribution of waterfowl across the survey area. Drought conditions and higher than average temperatures persisted across much of the southeastern United States, but timely rains and coastal marsh habitats likely provided key habitat for waterfowl in the Gulf Coast region.

Mattamuskeet, Breton, Pea Island, Delta, Lacassine, and Sabine NWRs, all coastal refuges, contained >70,000 waterfowl during their respective survey periods. Wheeler NWR and Catahoula Lake, refuges containing larger more stable bodies of water also contained >70,000 waterfowl during their respective surveys. Survey results suggested that dabbling and diving

ducks used stable water sources such as inland lakes, and the more southerly marshes on Atlantic and Gulf Coasts to access resources. Surveys conducted during the first two weeks of January 2026 coincided with abnormally warm weather with temperatures ranging from 50°F-80°F throughout the survey area. Average January temperatures range from 36°F in Paris, TN to 62°F in Orlando Florida (NCEI 2026). Additionally, nearly all the survey area was in a short-term moderate-severe drought (U.S. Drought Monitor 2026). Warm temperatures and minimal snow/ice coverage in the northern latitudes likely limited dabbling duck movements and migration through the Mississippi Alluvial Valley.

In 2026, the proportion of ducks counted on NWRs relative to partner-based counts in the Mississippi River Valley, Arkansas River Valley, and Louisiana Gulf Coast were down approximately 2% from 2025 (Marty et al. 2024). For example, the proportion of waterfowl using state and private lands in 2026 was greater than in 2025 in the Mississippi River Valley of Arkansas and Mississippi, and the Arkansas River Valley. Drought conditions throughout much of the survey region hindered the amount of flooded land NWRs could provide for waterfowl. Waterfowl likely bypassed these relatively dry habitats and continued migration to coastal habitats. The proportion of waterfowl using NWRs in the coastal zone of Louisiana increased from 2025 to 2026. This was likely due to wet conditions from timely rains prior to the survey period, resulting in increased foraging and loafing habitat on many areas that are not influenced by hunting pressure.

Waterfowl use-days recorded across surveyed National Wildlife Refuges (NWRs) declined between 2025 and 2026 for dabbling ducks and geese, while increasing for diving ducks, swans, and cranes. Despite these increases, use-days for diving ducks and cranes remained substantially below established use-day objectives.

These findings are consistent with observed shifts in waterfowl distribution, including a reduced proportion of ducks utilizing NWRs relative to state-managed and private lands. Furthermore, energy-day estimates have persistently fallen below target objectives for dabbling ducks, diving ducks, and cranes across multiple assessment periods.

Based on these trends, we recommend that current waterfowl population benchmarks and energy-day objectives for refuges within the region be reevaluated to ensure they accurately reflect contemporary habitat use patterns and management conditions.

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Table 1. Correction factors (CF) used to account for count bias in aerial waterfowl surveys.

Taxon	CF	Source
Dabbling ducks	1.08	Gilbert et al. (2020)
Diving ducks	1.18	Gilbert et al. (2020)
Geese	1.09	Gilbert et al. (2020)
Swans	1.05	Gilbert et al. (2020)
Ducks	1.12	Gilbert et al. (2020)
Other waterbirds	1.20	Gilbert et al. (2020)
Mallard	1.42	Gilbert et al. (2020)
Gadwall	1.08	general dabbling duck from Gilbert et al. (2020)
Northern shoveler	1.08	general dabbling duck from Gilbert et al. (2020)
Teal (GWTE & BWTE)	1.08	general dabbling duck from Gilbert et al. (2020)
Northern pintail	1.08	general dabbling duck from Gilbert et al. (2020)
American wigeon	3.90	Gilbert et al. (2020)
American black duck	1.08	general dabbling duck from Gilbert et al. (2020)
Wood duck	1.48	general dabbling duck from Gilbert et al. (2020)
Mottled duck	1.08	general dabbling duck from Gilbert et al. (2020)
Ring-necked duck	1.08	general dabbling duck from Gilbert et al. (2020)
Scaup (LESC & GRSC)	2.83	Gilbert et al. (2020)
Canvasback	1.45	Gilbert et al. (2020)
Bufflehead	2.55	Gilbert et al. (2020)
Common goldeneye	1.38	Gilbert et al. (2020)
Ruddy duck	1.18	general diving duck from Gilbert et al. (2020)
Redhead	2.13	Gilbert et al. (2020)
Hooded merganser	1.49	Gilbert et al. (2020)
Merganser (COME & RBME)	1.49	hooded merganser from Gilbert et al. (2020)
Scoter (WWSC, SUSC, & BLSC)	1.18	general diving duck from Gilbert et al. (2020)
Snow goose (LSGO, GRSG, ROGO)	1.61	>8000 SNGO estimate from Boyd (2000)
Greater white-fronted goose	2.0	Hines et al. (2003) & Gilbert et al. (2020)
Canada goose	1.07	Gilbert et al. (2020)
Swan (TUSW, TRSW, MUSW)	1.05	Gilbert et al. (2020)
American coot	1.63	Gilbert et al. (2020)
Sandhill crane	1.07	Gilbert et al. (2020)
Whooping crane	1.07	Gilbert et al. (2020)
Bald eagle	1	No correction factor known

Table 2. Habitat resource type and transect width used during aerial waterfowl surveys.

Habitat Resource Type	Code	Explanation	Transect width (m)
Mix	MX	Mix of habitat resource types in close proximity so assigning birds to only 1 is impractical.	200
Open Water	OW	Large areas of generally deep, open water such as lakes, ponds, reservoirs, bay, lagoons, impounded river pools, etc. <30% emergent or floating leaf vegetation. Mudflats are included in OW.	200
Seasonal Emergent	SE	Managed moist-soil with primarily annual plants low-growing near water surface. Millet, buckwheat, and other small grain crops may fall in this category; includes Unharvested rice and other shorted emergent plants	200
Forested/scrub-shrub	FO	Forested and scrub-shrub wetlands with >30% woody vegetation	100
Perennial Emergent Marsh	PE	>30% emergent vegetation cover that is tall / persistent, such as <i>Typha</i> spp., <i>Phragmites</i> spp., <i>Spartina</i> spp., etc.	200
Open-Emergent	OE	Mixture of <30% emergent vegetation, floating-leaved vegetation, and open water; including aquatic bed	200
Harvested Cropland	HC	Harvested cropland with minimal emergent vegetation (<30%) that is >0.5 m	200
Unharvested Corn	UC	Unharvested corn / sorghum	100
Unharvested Other	UO	Unharvested other	200

Table 3. Abundance of waterfowl and cranes by guild and National Wildlife Refuge estimated during January 2026 through aerial surveys in the southeastern United States.

Complex/Area	NWR	Dabbling Ducks	Diving Ducks	Geese	Swans	Cranes	Total Waterfowl	Total Waterbirds
Alabama	Wheeler NWR	22,894	9,343	20,129	0	19,534	71,901	71,901
Central Arkansas	Bald Knob NWR	5,748	81	6,540	0	0	12,369	12,369
	Big Lake NWR	3,565	432	8	0	0	4,005	4,122
	Cache River NWR	12,472	77	7,794	0	0	20,343	20,343
	Holla Bend NWR	688	403	49	0	0	1,140	1,140
	Wapanocca NWR	10,668	9,742	451	0	0	20,861	20,918
	White River NWR	38,075	2,526	97	0	0	40,698	40,698
Central Louisiana	Catahoula NWR	123,065	88,813	0	0	0	211,878	211,878
	Grand Cote NWR	8,866	24	0	0	0	8,889	8,889
	Lake Ophelia NWR	44,244	4,388	0	0	0	48,632	48,632
Gulf Coast	Grand Bay NWR	56	227	0	0	0	282	282
North Louisiana	Black Bayou NWR	2	199	0	0	0	201	204
	Darbonne NWR	1,467	0	0	0	0	1,467	1,467
	Handy Brake NWR	0	0	0	0	0	0	0
	Red River NWR	3,674	1,485	1,910	0	0	7,069	7,069
	Tensas River NWR	18	0	0	0	0	18	18
	Upper Ouachita NWR	958	0	0	0	0	958	958
North Mississippi	Coldwater NWR	8,696	0	190	0	0	8,886	8,886
	Dahomey NWR	201	2	0	0	0	203	203
	Noxubee NWR	704	276	3	0	0	982	1,233
	Tallahatchie NWR	9,965	0	12,880	0	0	22,845	22,845
South Arkansas	Felsenthal NWR	3,366	79	0	0	0	3,444	14,084
	Overflow NWR	7,169	0	13,870	0	0	21,039	21,039
	Big Branch Marsh NWR	1,309	209	0	0	0	1,518	3,251
	Breton NWR	0	90,204	0	0	0	90,204	90,204
	Delta NWR	179,315	195,875	39,666	0	0	414,855	450,773
Bayou Sauvage Urban	Bayou Sauvage NWR	7,972	4,506	0	0	0	12,479	12,849
	Mandalay NWR	0	0	0	0	0	0	33

Southwest Louisiana	Cameron Prairie NWR	15,547	6,266	30	0	0	21,843	21,843
	Lacassine NWR	31,871	34,543	117,200	0	0	183,614	186,450
	Sabine NWR	166,406	50,004	2,642	0	0	219,052	224,104
Theodore Roosevelt	Hillside NWR	21	0	0	0	0	21	21
	Holt Collier NWR	38	19	0	0	0	58	58
	Mathews Brake NWR	404	0	0	0	0	404	404
	Morgan Brake NWR	6,810	32	6,590	0	0	13,432	13,432
	Panther Swamp NWR	14,713	4	15,940	0	0	30,657	30,657
	St. Catherine Creek NWR	9,173	209	0	0	0	9,383	9,383
	Yazoo NWR	3,007	89	805	0	0	3,901	3,901
West Tennessee	Chickasaw NWR	7,013	22	21,270	0	0	28,305	28,305
	Hatchie NWR	10,362	0	1,229	0	0	11,591	11,591
	Lake Isom NWR	6,119	0	400	0	0	6,519	6,641
	Lower Hatchie NWR	40,343	35	39	0	0	40,417	40,417
	Reelfoot NWR	23,596	0	6,450	0	0	30,046	30,046
Eastern North Carolina	Mattamuskeet NWR	217,264	45,097	9,663	14,948	0	286,972	286,972
	Cedar Island NWR	717	38	39,968	0	0	40,723	40,723
	Pocosin Lakes NWR	2,970	18,282	33,560	19,258	0	74,070	74,070
	Swanquarter NWR	11,770	13,302	0	32	0	25,103	25,103
	Alligator River NWR	279	0	0	1,416	0	1,696	1,696
	Mackay Island NWR	8,253	751	607	1,803	0	11,413	11,413
	Pea Island NWR	8,617	61,181	504	603	0	70,905	71,150
South Carolina	Ace Basin NWR	1,058	4,489	0	0	0	5,547	5,780
	Savannah NWR						0	
	Santee NWR	2,990	26,850	228	0	112	30,179	30,179
	Waccamaw NWR	0	0	0	0	0	0	0
	Cape Romain NWR	381	4,078	0	0	0	4,459	4,475
Florida	Merritt Island NWR	1,763	13,813	0	0	0	15,575	21,876
	St. Marks NWR	1,824	16,848	0	0	0	18,671	18,671
Tennessee	Tennessee NWR - Duck River	37,791	3,112	7,633	0	129	48,665	48,665
	Tennessee NWR - Big Sandy	5,722	2,866	2,067	0	48	10,704	10,704
	Tennessee NWR - Busseltown	738	0	101	0	0	839	839
	Cross Creeks NWR	7,260	1,288	6,612	0	0	15,160	15,160

^a Total Waterfowl Abundance includes dabbling ducks, diving ducks, geese, swans, cranes.

^b Total Waterbird Abundance includes dabbling ducks, diving ducks, geese, swans, cranes, American coots.

Table 4. Peak abundance by waterfowl guild estimated from a single midwinter aerial survey in January 2026 and fixed migration curves on National Wildlife Refuge in the southeastern United States following Hagy et al. (2022b).

Complex/Area	NWR	Dabbling Ducks	Diving Ducks	Geese	Swans	Cranes	Total Waterfowl
Alabama	Wheeler NWR	22,894	10,155	22,366	0	20,348	75,764
Central Arkansas	Bald Knob NWR	7,186	203	0	0	0	7,388
	Big Lake NWR	3,875	508	15	0	0	4,397
	Cache River NWR	29,097	91	5,455	0	0	34,642
	Holla Bend NWR	748	474	89	0	0	1,311
	Wapanocca NWR	11,596	11,461	43	0	0	23,100
	White River NWR	41,386	2,972	176	0	0	44,534
Central Louisiana	Catahoula NWR	125,577	126,875	0	0	0	252,452
	Grand Cote NWR	9,047	34	0	0	0	9,081
	Lake Ophelia NWR	45,147	6,269	0	0	0	51,415
Gulf Coast	Grand Bay NWR	59	324	0	0	0	383
North Louisiana	Black Bayou NWR	2	442	0	0	0	444
	Darbonne NWR	1,528	0	0	0	0	1,528
	Handy Brake NWR	0	0	0	0	0	0
	Red River NWR	3,749	3,299	2,076	0	0	9,125
	Tensas River NWR	19	0	0	0	0	19
	Upper Ouachita NWR	998	0	0	0	0	998
North Mississippi	Coldwater NWR	8,696	0	198	0	0	8,894
	Dahomey NWR	201	2	0	0	0	203
	Noxubee NWR	704	287	3	0	0	994
	Tallahatchie NWR	9,965	0	13,417	0	0	23,381
South Arkansas	Felsenthal NWR	3,506	175	0	0	0	3,681
	Overflow NWR	7,467	0	15,076	0	0	22,543
Southeast Louisiana	Big Branch Marsh NWR	1,378	298	0	0	0	1,676
	Breton NWR	0	128,863	0	0	0	128,863
	Delta NWR	203,767	208,377	15,571	0	0	427,716
Bayou Sauvage Urban	Bayou Sauvage NWR	8,392	6,438	0	0	0	14,829
	Mandalay NWR	0	0	0	0	0	0
Southwest Louisiana	Cameron Prairie NWR	16,365	8,951	50	0	0	25,366
	Lacassine NWR	33,549	49,347	66,613	0	0	149,509

	Sabine NWR	175,164	71,435	752	0	0	247,351
Theodore Roosevelt	Hillside NWR	21	0	0	0	0	21
	Holt Collier NWR	38	20	0	0	0	59
	Mathews Brake NWR	404	0	0	0	0	404
	Morgan Brake NWR	6,810	34	6,865	0	0	13,708
	Panther Swamp NWR	14,713	5	16,604	0	0	31,322
	St. Catherine Creek NWR	9,361	299	0	0	0	9,660
	Yazoo NWR	3,007	93	839	0	0	3,938
West Tennessee	Chickasaw NWR	7,090	25	22,389	0	0	29,505
	Hatchie NWR	11,023	0	1,254	0	0	12,278
	Lake Isom NWR	6,186	0	421	0	0	6,607
	Lower Hatchie NWR	42,467	36	42	0	0	42,545
	Reelfoot NWR	25,102	0	6,582	0	0	31,684
Eastern North Carolina	Mattamuskeet NWR	231,132	46,976	24,157	33,973	0	336,239
	Cedar Island NWR	732	42	0	0	0	773
	Pocosin Lakes NWR	3,159	19,044	83,901	43,769	0	149,873
	Swanquarter NWR	12,521	13,856	0	72	0	26,449
	Alligator River NWR	328	0	0	4,722	0	5,050
	Mackay Island NWR	8,421	825	949	2,404	0	12,599
	Pea Island NWR	14,362	63,730	1,261	2,009	0	81,362
South Carolina	Ace Basin NWR	1,080	4,627	0	0	0	5,707
	Savannah NWR	0	0	0	0	0	0
	Santee NWR	3,051	27,680	232	0	112	31,074
	Waccamaw NWR	0	0	0	0	0	0
	Cape Romain NWR	388	4,204	0	0	0	4,593
Florida	Merritt Island NWR	1,959	14,095	0	0	0	16,053
	St. Marks NWR	1,940	16,848	0	0	0	18,788
Tennessee	Tennessee NWR - Duck River	38,960	3,275	8,297	0	139	50,671
	Tennessee NWR - Big Sandy	5,899	3,017	2,247	0	52	11,215
	Tennessee NWR - Busseltown	761	0	109	0	0	870
	Cross Creeks NWR	7,484	1,356	7,187	0	0	16,027

Table 5. Total use days by waterfowl guild for 1 October – 30 April and total waterfowl energy days estimated from a single midwinter aerial survey in January 2026 and fixed migration curves on National Wildlife Refuge in the southeastern United States following Hagy et al. (2022*b*).

Complex/Area	NWR	Dabbling Ducks	Diving Ducks	Geese	Swans	Cranes	Total WEDs
Alabama	Wheeler NWR	1,232,458	676,829	1,267,656	0	1,032,834	9,674,383
Central Arkansas	Bald Knob NWR	438,104	12,065	1,618,644	0	0	5,303,085
	Big Lake NWR	230,569	26,581	812	0	0	252,941
	Cache River NWR	1,731,493	4,749	304,489	0	0	2,648,523
	Holla Bend NWR	44,506	24,870	4,983	0	0	78,108
	Wapanocca NWR	690,067	599,403	45,660	0	0	1,276,600
	White River NWR	2,462,788	155,425	9,813	0	0	2,608,796
Central Louisiana	Catahoula NWR	7,206,086	6,360,127	0	0	0	11,976,181
	Grand Cote NWR	519,129	1,702	0	0	0	520,405
	Lake Ophelia NWR	2,590,704	314,241	0	0	0	2,826,384
Gulf Coast	Grand Bay NWR	4,312	20,588	0	0	0	19,753
North Louisiana	Black Bayou NWR	130	24,098	0	0	0	18,204
	Darbonne NWR	88,539	0	0	0	0	88,539
	Handy Brake NWR	0	0	0	0	0	0
	Red River NWR	215,158	179,811	94,069	0	0	632,224
	Tensas River NWR	1,114	0	0	0	0	1,114
	Upper Ouachita NWR	57,810	0	0	0	0	57,810
North Mississippi	Coldwater NWR	650,294	0	10,185	0	0	680,848
	Dahomey NWR	15,030	148	0	0	0	15,141
	Noxubee NWR	52,611	18,880	172	0	0	67,288
	Tallahatchie NWR	745,128	0	690,417	0	0	2,816,380
South Arkansas	Felsenthal NWR	203,145	9,540	0	0	0	210,300
	Overflow NWR	452,079	0	741,154	0	0	2,675,540
Southeast Louisiana	Big Branch Marsh NWR	118,174	18,970	0	0	0	132,402
	Breton NWR	0	8,199,532	0	0	0	6,149,649
	Delta NWR	17,473,035	13,244,457	4,260,754	0	0	40,188,640
Bayou Sauvage Urban	Bayou Sauvage NWR	719,610	409,620	0	0	0	1,026,824
	Mandalay NWR	0	0	0	0	0	0

Southwest Louisiana	Cameron Prairie NWR	1,403,318	568,934	2,256	0	0	1,836,786
	Lacassine NWR	2,874,439	3,133,047	8,812,471	0	0	31,661,637
	Sabine NWR	15,020,331	4,540,399	198,630	0	0	19,021,522
Theodore Roosevelt	Hillside NWR	1,593	0	0	0	0	1,593
	Holt Collier NWR	2,867	1,327	0	0	0	3,862
	Mathews Brake NWR	30,191	0	0	0	0	30,191
	Morgan Brake NWR	509,232	2,220	353,249	0	0	1,570,644
	Panther Swamp NWR	1,100,207	296	854,445	0	0	3,663,764
	St. Catherine Creek NWR	537,145	14,996	0	0	0	548,392
	Yazoo NWR	224,826	6,115	43,151	0	0	358,865
West Tennessee	Chickasaw NWR	488,848	1,676	1,332,174	0	0	4,486,626
	Hatchie NWR	760,003	0	74,632	0	0	983,898
	Lake Isom NWR	426,520	0	25,053	0	0	501,678
	Lower Hatchie NWR	2,927,829	2,386	2,521	0	0	2,937,182
	Reelfoot NWR	1,730,646	0	391,611	0	0	2,905,480
Eastern North Carolina	Mattamuskeet NWR	17,498,394	3,080,318	833,616	1,831,165	0	31,465,305
	Cedar Island NWR	55,403	2,728	2,157,645	0	0	6,530,384
	Pocosin Lakes NWR	239,178	1,248,714	2,895,264	2,359,146	0	21,657,237
	Swanquarter NWR	947,962	908,547	0	3,859	0	1,648,666
	Alligator River NWR	24,388	0	0	254,497	0	1,296,870
	Mackay Island NWR	637,569	54,104	32,751	129,560	0	1,424,199
	Pea Island NWR	956,744	4,178,901	43,512	108,285	0	4,762,883
South Carolina	Ace Basin NWR	69,650	303,189	0	0	0	297,042
	Savannah NWR	0	0	0	0	0	0
	Santee NWR	196,846	1,811,640	13,422	0	6,102	1,620,251
	Waccamaw NWR	0	0	0	0	0	0
	Cape Romain NWR	25,063	275,472	0	0	0	231,667
Florida	Merrit Island NWR	163,025	1,148,420	0	0	0	1,024,340
	St. Marks NWR	141,774	1,114,451	0	0	0	977,612
Tennessee	Tennessee NWR - Duck River	2,971,580	216,223	493,686	0	6,284	4,639,942
	Tennessee NWR - Big Sandy	449,956	199,152	133,687	0	2,350	1,009,783
	Tennessee NWR - Busseltown	58,025	0	6,505	0	0	77,540
	Cross Creeks NWR	570,862	89,392	427,641	0	0	1,920,828

¹ A waterfowl energy day is equivalent to the approximate energy needs of one mallard-sized duck for one day (300 kcal) and can be adjusted by multiplication factors according to body mass for other taxa (diving ducks = 0.7 WED, geese = 3 WED, swans = 5 WEDs, cranes = 4 WEDs).

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