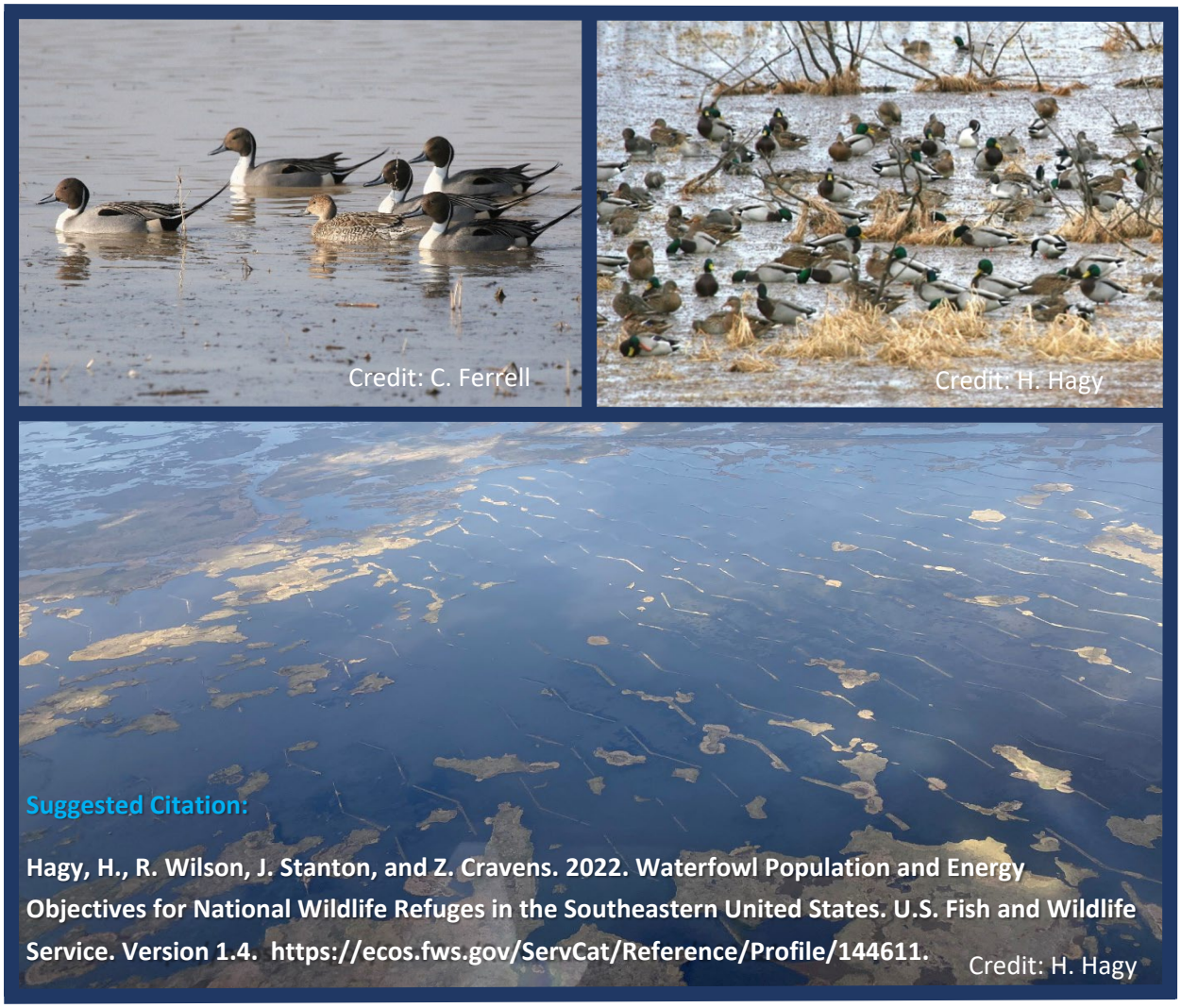
U.S. Department of the Interior

U.S. Fish and Wildlife Service

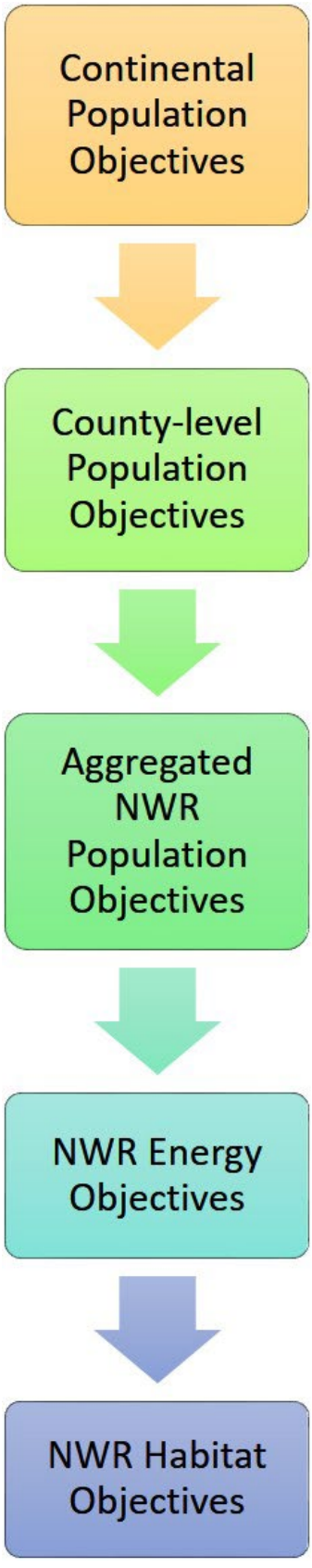
National Wildlife Refuge System

Waterfowl Population and Energy Objectives for National Wildlife Refuges in the Southeastern United States



Version 1.4 **December 2022**

Introduction



Clear conservation objectives are important for prioritizing resource management and allocation on National Wildlife Refuges (NWR). Moreover, objectives based on the best available science are consistent with U.S. Fish and Wildlife Service (USFWS) policy (Hagy et al. 2021). As defined in the Fish and Wildlife Service Manual (602 FW 1.6N), an objective is a "*concise statement of what we want to achieve, how much we want to achieve, when and where we want to achieve it, and who is responsible for the work.*" Moreover, "*objectives derive from goals and provide the basis for determining strategies, monitoring refuge accomplishments, and evaluating the success of strategies making objectives attainable, results-oriented, time-specific, and measurable.*" Given that waterfowl are a priority taxon for resource allocation and management on most NWRs in the Southeast, clear and biologically derived objectives are critical for effective adaptive resource management.

The USFWS Southeast Region (hereafter, Southeast) currently includes 131 NWRs with a wide variety of natural and cultural resources, establishing purposes and missions, and partner support. More than 50% of these NWRs include waterfowl management as a priority and almost all provide habitat resources for waterfowl. The Southeast spans two North American Flyways, six Migratory Bird Joint Venture regions, and ten states. Waterfowl conservation and management on NWRs is coordinated with state, other federal, and non-governmental organization partners to implement the North American Waterfowl Management Plan (NAWMP), but the geographical extent and diversity of the Southeast coupled with administrative complexity presents challenges. For example, Migratory Bird Joint Ventures, the primary partnerships charged implementing the NAWMP, overlapping the Southeast have varying spatial information, administrative and analytical processes, and resources to support development of conservation objectives for waterfowl on NWRs. Ideally, conservation objectives for waterfowl on NWRs should be science based, biologically derived, defensible, stepped down from the NAWMP, and complimentary with philosophies and planning frameworks of conservation partners (e.g., Joint Ventures, State Wildlife Agencies, etc.).

Despite the clear need, a consistent process for developing waterfowl conservation objectives for NWRs has not been implemented previously for the entire Southeast. For example, some NWRs may have waterfowl objectives based on peak counts, desired conditions set by best

professional judgment, or energy modeling developed in partnership with Joint Ventures. Moreover, processes used to establish these objectives vary not only across the Southeast but also across individual NWRs. Some challenges include underlying analyses that typically were not extensively documented or inconsistently included in a variety of planning documents (e.g., Comprehensive Conservation Plans [CCP], Habitat Management Plans [HMP], Biological Reviews, etc.) and/or existing objectives are based on outdated information or processes that should be updated based upon the latest science (Petrie et al. 2007; Fleming et al. 2017, 2019). Furthermore, waterfowl objectives are currently expressed in a variety of different formats, including as population (e.g., peak counts, use days), energy (e.g., duck energy days), or habitat objectives (e.g., acres of managed moist-soil vegetation), and some NWRs with important habitat resources for waterfowl have no explicit or empirical objectives for waterfowl. These inconsistencies were formally recognized at the Southeast Region's 2015 NWR Waterfowl Summit held at Wheeler NWR and resulted in two Action Items (2.1 and 2.2) in the Strategic Action Plan for Waterfowl Management in the Southeast administered by the NWR System Waterfowl Working Group (USFWS 2016).

Despite the lack of consistency across the region, several Joint Ventures have established state-level waterfowl conservation objectives and made progress in assessing the present capacities of NWRs to contribute to those objectives within their geographies. For example, the Lower Mississippi Valley and Gulf Coast Joint Ventures have stepped-down energy and/or habitat objectives to their geographies using a bioenergetics approach (Wilson et al. 2003; Lower Mississippi Valley Joint Venture 2012, 2015). The Atlantic Coast Joint Venture has established habitat objectives for focal areas within states using expert opinion (ACJV 2005) as well population objectives for ten common species by state. The East Gulf Coastal Plain and Central Hardwoods Joint Ventures do not have state or regional objectives for waterfowl, currently. There are currently no NWRs that provide substantial habitat resources for waterfowl within the portion of the Appalachian Mountains Joint Venture geography overlapping the Southeast Region. Thus, a consistent process for setting waterfowl objectives on NWRs should accommodate the variation in regional waterfowl planning methods and progress.

Setting conservation objectives for waterfowl on NWRs in the Southeast requires an understanding of the role that NWRs, and the Southeast Region in general, play in conservation of continental waterfowl populations. The NWR System primarily contributes to conservation of continental waterfowl populations through provision of food and sanctuary during autumn and winter in the Southeast. Supplying a portion of these resources on NWRs distributes waterfowl across the landscape making them available to waterfowl watchers and hunters who, in turn, support continental habitat conservation through license sales, conservation stamp sales, taxes, and sociopolitical efforts. While the effect of sanctuary on waterfowl is poorly understood (Hagy et al. 2017), there is some consensus in the conservation community that food availability during the non-breeding period may influence demographic rates of some waterfowl populations in some years and is a suitable metric on which to base conservation objectives (Esslinger and Wilson 2001, Wilson et al. 2003, Petrie et al. 2011, Lower Mississippi Valley Joint Venture 2015). Thus, considerable research has been conducted on food availability for waterfowl during the

non-breeding period to support bioenergetics models (Williams et al. 2014). In some geographies, such as in portions of the lower Mississippi Alluvial Valley and the adjacent Gulf Coast, the amount of energy available has been estimated through a large number of field studies and analyses of geospatial data. These estimates of available energy can be scaled up to the landscape level to estimate total energy supply for waterfowl.

For comparison, energy requirements can also be estimated by stepping down population goals from the NAWMP using hunter harvest or waterfowl monitoring data. For example, the Lower Mississippi Valley Joint Venture estimated that Arkansas provided ~124 million duck energy days (i.e., a measure of food energy equivalent to the caloric needs of one mallard-sized duck for 1 day) during winters 2011–2014. However, an analysis of energy demand indicated that Arkansas needed an additional 95 million duck energy days to meet current energy requirements of wintering and migrating waterfowl (Lower Mississippi Valley Joint Venture 2015). Given the availability of information and extensive work already conducted by conservation partners, we believe waterfowl conservation objectives for NWRs in the Southeast should be established using similar energetic criteria until other metrics become available in the future. We acknowledge that waterfowl conservation involves many factors in additional to supplying adequate food, but insufficient information currently exists to develop quantifiable metrics based on potential biological requirements for space, sanctuary, pair bonding, and other factors. Thus, we fully acknowledge that provision of energy is only one of several important components required by waterfowl during the non-breeding period, and NWR managers will need to carefully consider landscape context, species composition, and non-breeding ecology to supply a diversity of resources that meet the needs of waterfowl during the non-breeding period.

Goals and Objectives

Our goal was to develop waterfowl conservation objectives for NWRs across the Southeast in a transparent manner that was consistent, as compatible as practical with existing planning efforts of conservation partners, and clearly linked to the NAWMP (Petrie et al. 2007). Using this general goal, we developed a process to create population and energy objectives that were 1) clearly stepped down from the NAWMP to individual NWRs, 2) directly linked to biological processes and consistent with the best available science; 3) robust to differing philosophies and planning processes among States, Joint Ventures, Flyways, and other conservation partners; 4) derived using a consistent process across all NWRs in the Southeast that was transparent, defensible, and clearly documented; and 5) easily updatable as additional information becomes available (Hagy et al. 2020). A consistent and clearly documented process for establishing waterfowl objectives will better enable coordinated monitoring efforts and lead to more effective adaptive resource management on NWRs in the Southeast.

Methods

Establishing County-level Population Objectives

We followed the process outlined by Fleming et al. (2017, 2019) to step down continental population objectives to National Wildlife Refuges in the Southeast. Fleming et al. (2017, 2019) established population objectives for dabbling and diving ducks using continental population objectives from the NAWMP scaled (i.e., stepped down) to counties using harvest data from the U.S. Fish and Wildlife Service. We assumed that harvest data provided an index of waterfowl population and hunter distribution and abundance that was the best available dataset to step-down continental population objectives consistent with the three goals of NAWMP. These goals include 1) maintaining abundant and resilient waterfowl populations, 2) conserving wetlands that provide waterfowl habitat and ecological services, and 3) growing numbers of waterfowl hunters and other conservationists. Specifically, we assumed that using harvest data would provide an index of distribution on the landscape to enable the biological needs of waterfowl to be met and it would help spread those habitat resources across NWRs on the landscape to support equitable waterfowl hunting and watching (Salyer 1945).

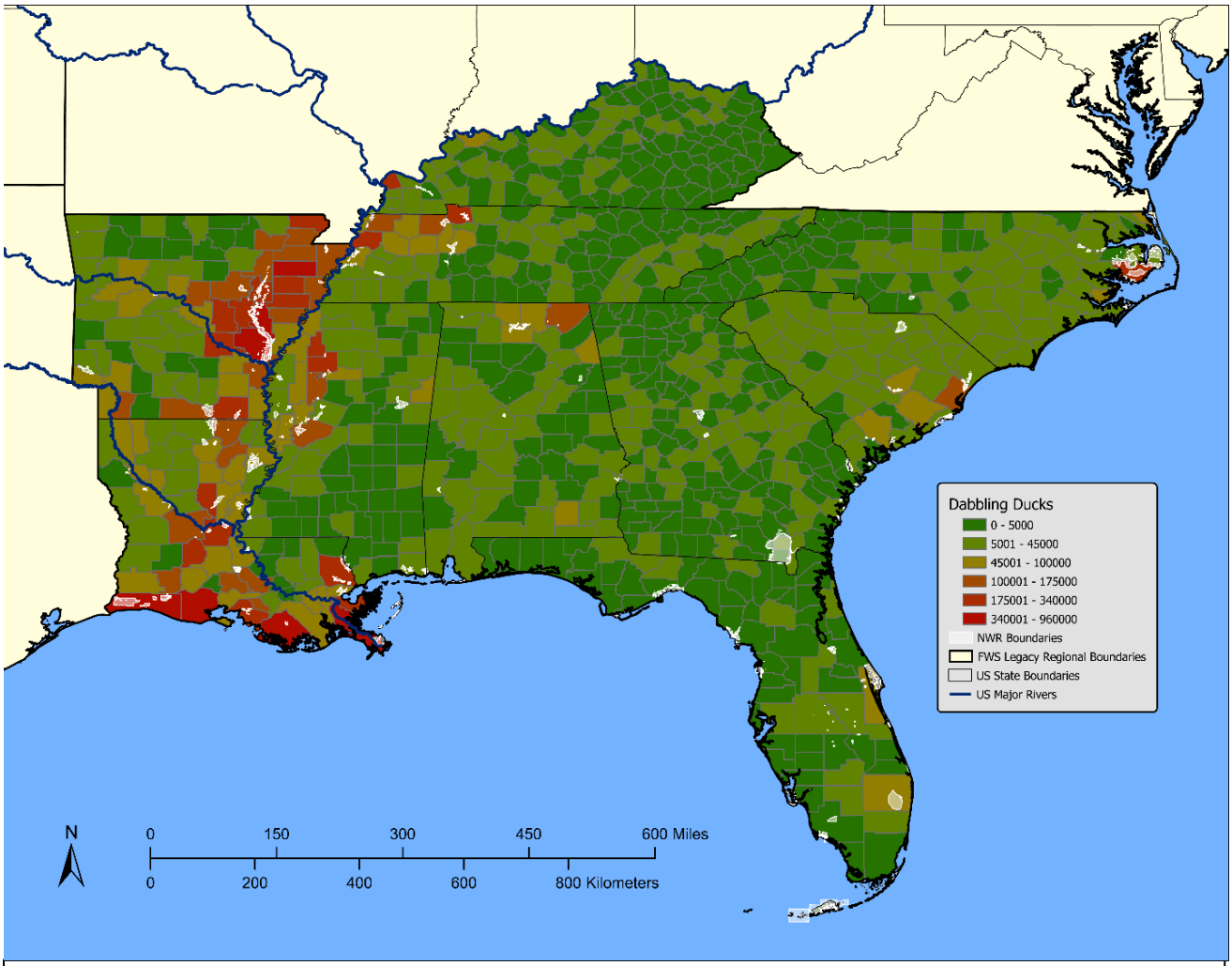


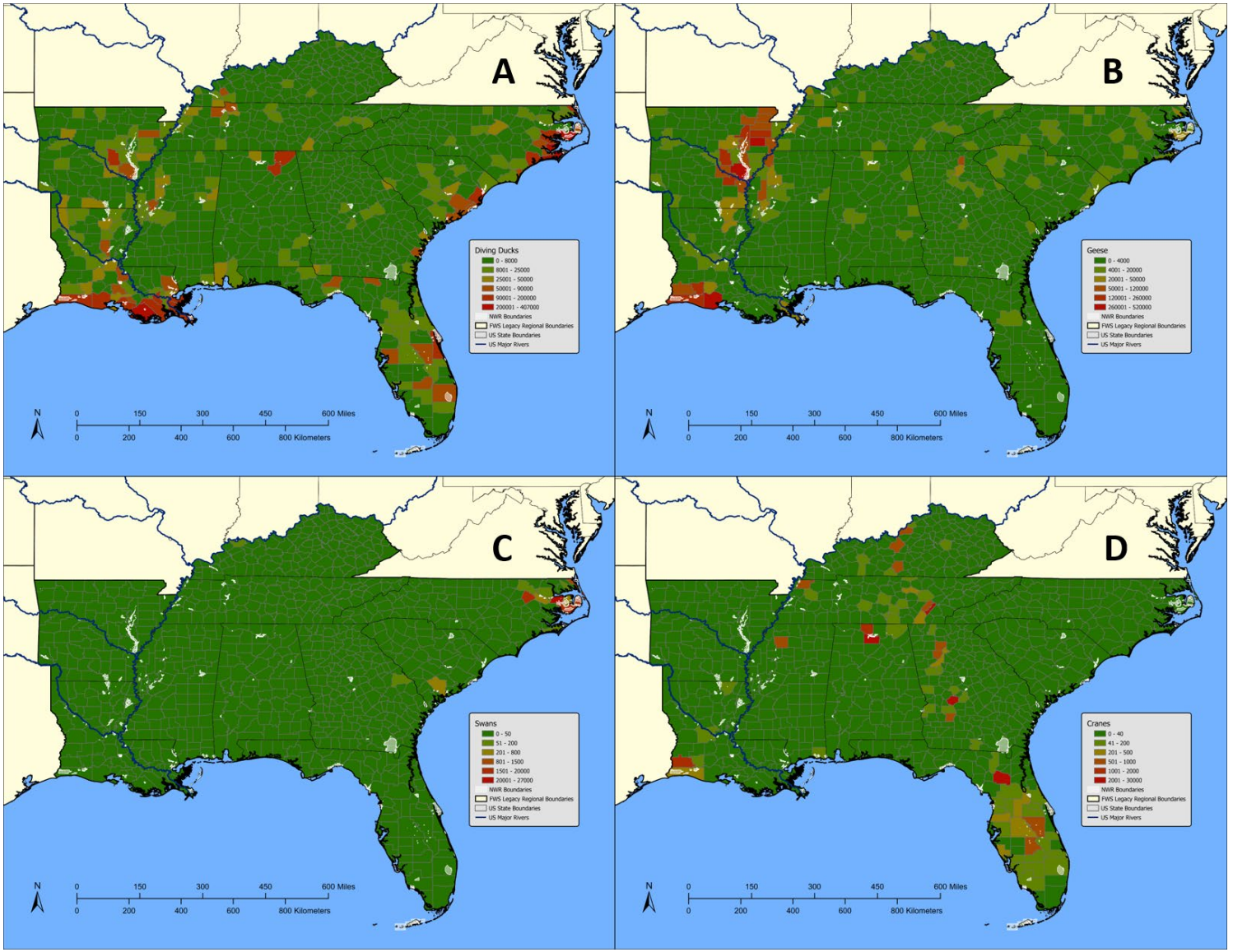
Figure 1. Relative density of dabbling duck population objectives within counties and parishes in the Southeast with respect to National Wildlife Refuge boundaries.

Harvest data were derived using the harvest information program database as a sampling frame and daily hunting diary survey (n = 104,820 hunters surveyed in 2018) and parts collection survey data (n = 4,870 hunters in 2018) to estimate hunter harvest and activity for each state by species (Raftovich et al. 2018). Fleming et al. (2019) developed population objectives for ducks by scaling both the long-term average (LTA) and 80th percentile of the LTA of continental breeding population sizes to total population size during winter (including a correction for recruitment and subsequent mortality). They summed harvest across 1999–2013 to create an index of distribution across the United States, Canada, and Mexico. They divided harvest into autumn (1 Sep–30 Nov) and winter (1 Dec–31 Jan) time periods to partition harvest among areas that may primarily serve as either migration or wintering areas for ducks. As our primary focus of this analysis was the southeastern United States that primarily serve as wintering areas for most waterfowl taxa, we selected the winter period for dabbling and diving ducks. Additionally, we selected the 80th percentile of the LTA to ensure that objectives accounted for not only the average population size, but also population size in most years (Method 4d; Fleming et al. 2017, 2019). Thus, county-level population objectives included the 23 most commonly harvested duck species present in North America during autumn and winter. We consolidated county-level objectives across species of dabbling and diving ducks to create guild-level (i.e., dabbling duck, diving duck) objectives for each county (Fig. 1). We chose to aggregate species at the guild level because habitat managers typically focus on guilds rather than individual species and because harvest data for several species was limited at our spatial scale.

County-level population objectives for geese were not available in Fleming et al. (2019), so we used county-level harvest data following Fleming et al. (2019) to create county-level population objectives for Canada and cackling (combined), lesser and greater snow (combined), Ross's, and greater white-fronted geese, and Atlantic and black brant. Because snow, Ross's and greater white-fronted geese typically migrate to wintering areas by early December and most Canada goose harvest in the Southeast comes from temperate-breeding populations that have limited autumn migrations, we did not partition goose harvest into temporal periods. Although this could theoretically negatively bias harvest for mid-latitude migration areas, especially for subarctic-breeding Canada geese, we believe those biases to be low for southeastern states due to low abundances of migrant Canada geese relative to more northern states.

Following Fleming et al. (2019), we multiplied county-level harvest, expressed as a proportion of the total harvest in the U.S., Canada, and Mexico, by total population size for each goose taxon. To estimate autumn population size for each goose taxon, we used a combination of breeding population estimates from the 2018 U.S. Fish and Wildlife Service Waterfowl Population Status Report, continental objectives from the 2018 NAWMP, and mean population size during 2008–2017 from the 2018 NAWMP (U.S. Fish and Wildlife Service 2018, Appendix D, E). Because population estimates from geese come from a variety of sources and may represent different proportions of the actual North American population size (e.g., breeding population estimate, fall survey estimate, Lincoln-Peterson estimates), we adjusted each of these estimates to account for recruitment and/or survival between the estimate time period and the peak autumn population size. We selected the maximum adjusted estimate from these data sources for each

Figure 2. Relative density of diving duck (A), goose (B), swan (C), and crane (D) population objectives within counties and parishes in the Southeast with respect to National Wildlife Refuge boundaries.



taxon of geese, as the mean population size was greater than the continental objectives for some species (e.g., Ross's geese). Our rationale was that step-down objectives should account for all geese likely to use a NWR, as they may compete with ducks and other wetland-dependent species for habitat resources, such as food. This rationale is consistent with current waterfowl objective processes used by the Lower Mississippi Valley and Gulf Coast Joint Ventures. Finally, we consolidated county-level objectives across goose species to create a combined "goose" objective for each county, similar to the dabbling and diving duck guilds.

Similar county-level harvest data was not available across the range of swans and cranes, as harvest is restricted unequally within and among states likely violating the assumption that harvest distribution provides an index of actual distribution on the landscape. Thus, we used eBird observations to create an index of swan and crane distribution using the same rationale and process and harvest data. Similar to Fleming et al. (2019), we summed counts recorded in eBird across the eastern United States (Mississippi and Atlantic flyways) during 1 December to 31 January 2012–2017 by county and multiplied the proportion of those counts to the sum of all counts by the population size. We assumed the eastern population of cranes was 120,000 (Dubovsky 2018; J. Brunjes, personal communication) and excluded Central and Pacific Flyway populations. We assumed a population size of 150,000 for eastern tundra, trumpeter, and mute swan populations combined (Atlantic Flyway Council 2003; USFWS 2017, 2019). Any eBird entries noting that swans or cranes were "present" rather than listing a count were censored (Fig. 2).

Allocating County-level Objectives to National Wildlife Refuges

We reviewed NWR Comprehensive Conservation Plans for establishing language, primary purposes, and goals to build a list of NWRs where waterfowl were a resource of concern. We included NWRs that had "migratory birds" or "inviolate sanctuary" in their establishing purposes in our objectives-setting analysis. Additionally, we included NWRs that had "wildlife" or "wetland" in their primary purposes if CCPs or other NWR documentation included waterfowl in their goals or indicated specifically that waterfowl were a resource of concern. We interviewed NWR complex staff and used concurrent workshops lead by the regional Inventory and Monitoring Branch to help NWRs prioritize resources of concern to validate our list (Appendix A).

Following a review of published literature and evaluation of various buffer sizes (Hagy et al. 2020), we assumed 50 km was a reasonable and biologically defensible distance by which NWRs could influence waterfowl conservation across the entire winter period (Bellrose and Crompton 1970; Cox and Afton 1996, 2000; Fleskes et al. 2002; Brochet et al. 2009; Legagneux et al. 2009; Davis and Afton 2010, Beatty et al. 2014, , Newcomb 2014; Yetter et al. 2018; J. Lancaster, unpublished data; D. Osborne, unpublished data). We acknowledge that daily movement distances are often less than our estimate of 50 km, but we lacked data from most species in most regions to characterize a total winter home range relevant for conservation planning purposes and assumed that winter movements of ducks across the entire winter and migration period encompassed areas of at least the size of our buffered areas (Hagy et al. 2020).

We generated 50-km buffers around the main body of each NWR unit and allocated county-level population objectives to each NWR equivalent to the proportion of each county overlapped by the buffer. For example, if a buffer overlapped 80% of a county, 80% of the total population objective from that county was allocated to the buffered NWR. Small tracts, easements, and those units lacking significant management capability and located long distances from the main NWR unit were omitted so as not to inflate artificially buffer sizes and resulting objectives. In situations where buffers from multiple NWRs overlapped the same portion of a county, objectives were scaled according to the proportional area included in the overlap relative to the entire county and then divided among NWRs according to current management capacity (Fig. 3). We used existing NWR spatial data (Hagy et al. 2019) and data from the National Wetland Inventory to create an index of current energy production and management capability on NWRs in the Southeast (Table 1). We multiplied acreages of wetland types by their approximate energy values to create the energy index (Gray et al. 2013). Thus, NWRs with greater current management capacity received a larger portion of objective in portions of counties where buffers overlapped. We also included NWRs outside of the Southeast regional boundary where 50-km buffers might overlap with NWRs inside the regional boundary in this index calculation. After splitting county level population objectives among nearby NWRs, objectives were summed across all counties included within the buffer for each NWR and this summed total represented the population objective for each NWR.

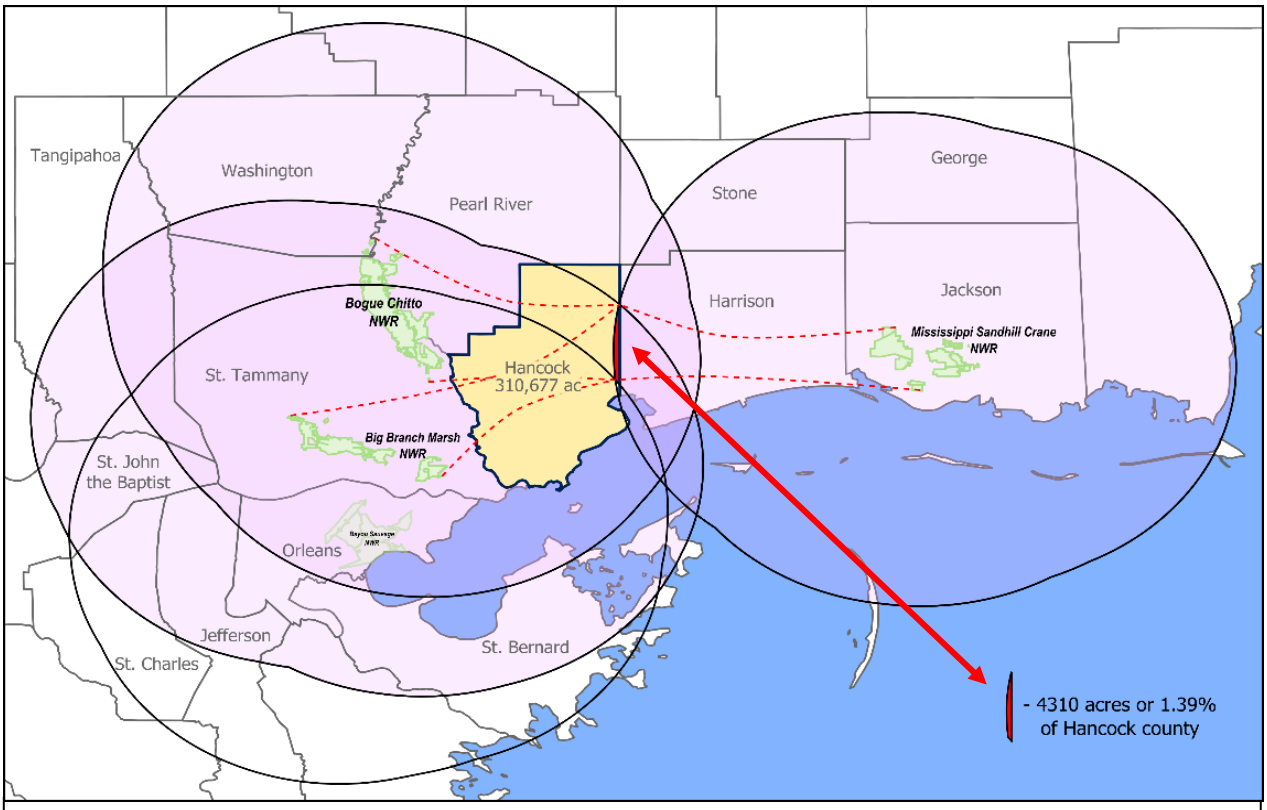


Figure 3. 50-km buffers around Big Branch, Bogue Chitto, Bayou Sauvage, and Mississippi Sandhill Crane National Wildlife Refuges showing shared portion of Hancock County, MS, USA.

Estimating Total Use Days

To estimate use days, the total population objective for each guild within each NWR was extrapolated across the entire migration and winter period (1 October – 30 April), excluding some early-migrating species where limited management efforts are currently focused (e.g., blue-winged teal), using a migration curve to generate total use days (Fig. 4). Traditionally, objectives for NWRs have been estimated by multiplying a fixed population estimate (e.g., midwinter waterfowl survey count) by a fixed estimate of duration of stay (e.g., 110 days; Johnson and Orr 2002). However, use of migration curves as advocated by Soulliere et al. (2013) and previously used by the Gulf Coast Joint Venture (Esslinger and Wilson 2001) represent an advancement over this technique and may include data from local monitoring efforts (e.g., NWR counts) or citizen science (e.g., eBird). We built migration curves using eBird total counts summed across checklists from 1 October – 30 April. We accessed weekly count data from eBird checklists submitted for locations on NWRs, counties surrounding NWRs, nearby important bird areas, or the entire state in which NWRs were located if data were sparse (e.g., Louisiana). We selected 5 species of dabbling ducks (e.g., mallard, northern pintail, gadwall, green-winged teal, northern shoveler), 5 species of diving ducks and/or mergansers (e.g., canvasback, ring-necked duck, lesser scaup, bufflehead, hooded merganser), and 3-5 species of geese (e.g., snow goose, greater white-fronted goose, Canada goose, Ross's goose) as they occurred most frequently and abundantly within checklists that we

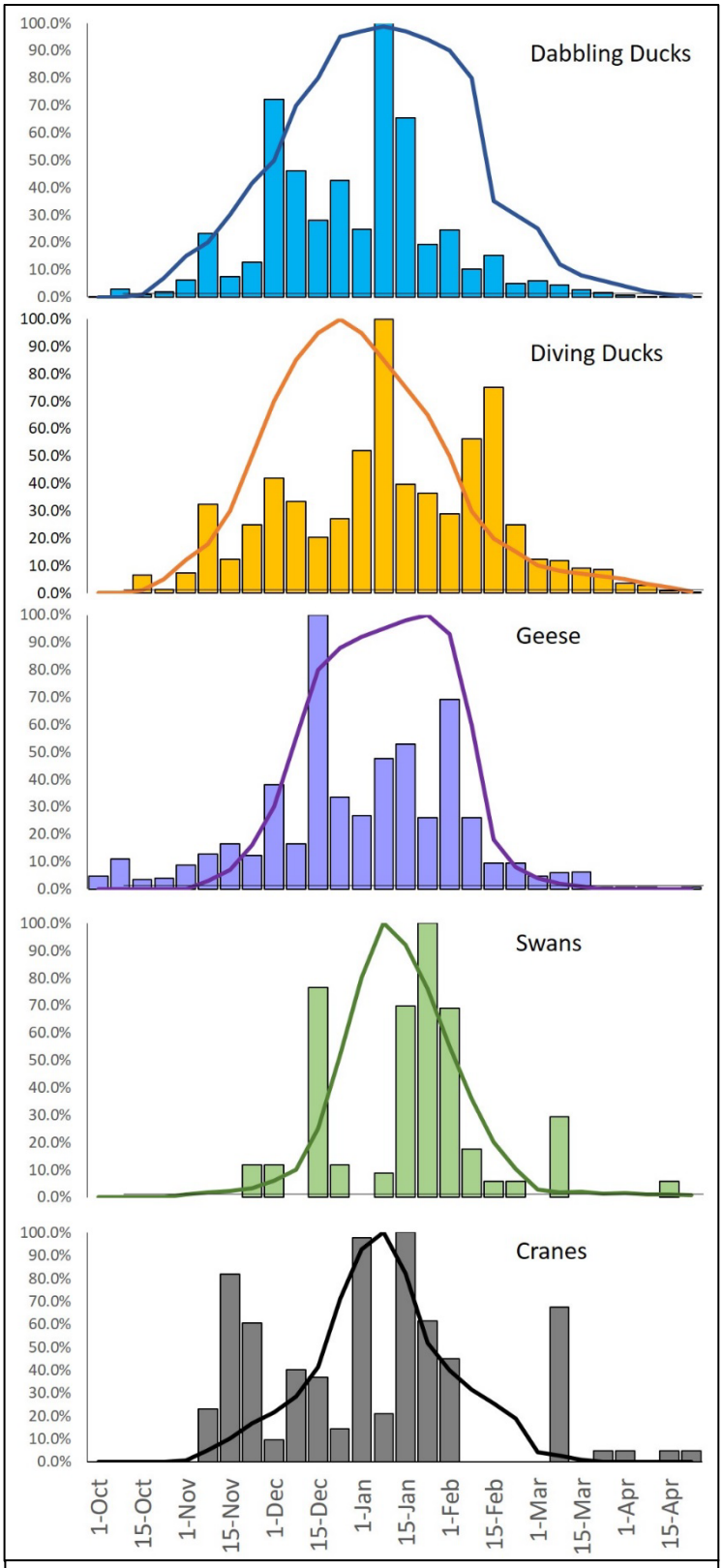


Figure 4. Mean weekly counts from eBird during 2012-2018 on National Wildlife Refuges in Tennessee and modified migration curves using local monitoring data and best professional judgement of local NWR staff.

examined region-wide. We allowed species to vary among locations to ensure that the most common species near individual NWRs were used to form migration curves. Generally, we used data from autumn 2012 – spring 2018, unless data from previous years substantially improved the apparent biological reasonableness of the curve. Where total counts from this 5-year period did not produce reasonable migration curves based on best professional judgement or consistent with available monitoring data, we used additional years or other metrics (e.g., average counts) to generate migration curves. Additionally, we used any local monitoring data available from NWRs, state wildlife management areas, or other sources to verify and refine migration curves as necessary (Fig. 4).

Counts were scaled for each week relative to the peak count for that year and then that proportion was multiplied by the total population objective from the NWR for each guild. We assumed that 95% of the total population estimate of ducks, swans, and cranes and 100% of the population estimate for geese occurred at the peak of the migration curve (i.e., migration anchor point). We chose a relatively high (at or near 100%) anchor point so as to avoid inflating estimates high. Although there is very limited information available to assess this assumption, data from Mississippi indicated that approximately 92% of surviving mallards marked with radio transmitters during November–December 2010–2011 were present during the subsequent January when the peak typically occurs within that geography (J. Lancaster, unpublished data). Additionally, 97% of mallards marked during November–December 2019 in west Tennessee remained throughout January 2020 (A. Blake-Bradshaw, unpublished data). Weekly abundance was then multiplied by 7 to generate total use days each week and summed across the entire winter period. In this analysis, total use days represented a population estimate extrapolated over time to be used primarily to estimate energy requirements of waterfowl on NWRs. Thus, total use days for each guild are equivalent to total guild-specific energy days. Subsequently, we converted guild-specific energy days to generic waterfowl energy days (WED) using fixed conversion factors to approximate the daily energy needs of a mallard-sized duck (300 kcal / day = 1 WED).

Adjusting Objectives for National Wildlife Refuge Share

Lastly, we assumed that NWRs would be responsible for a portion of the total energy days for each guild (i.e., dabbling ducks, diving ducks, geese, and swans) in the geographical area encompassed by their buffer (i.e., NWR share; Table 2). Where available, we used spatial data on the extent of natural flooding and area of managed wetlands completed by Joint Ventures to inform this allocation (Lower Mississippi Valley Joint Venture 2012, 2015). If other information was available to help inform the share size for a NWR, we adjusted the share size accordingly. As NWRs were originally intended as reservoirs to ensure maintenance of annual waterfowl "breeding stocks" (Salyer 1945), it seemed reasonable to adopt a general guideline that NWRs should provide food resources for approximately of one third of the populations that occur in their surrounding area, with the remaining proportion provided by a combination of natural flooding of unmanaged wetlands or floodplain areas; unflooded agricultural crops (primarily for geese, swans, and cranes); and other wetlands managed by state, other federal, non-

governmental, and private entities. However, share allocations were adjusted for individual NWRs during workshops with local NWR staff and partners. Share size was restricted (maximum = 50%, minimum = 5%) for sake of consistency, and spatial data, partner input, and best professional judgment were used to assign a share for each guild. For example, Tennessee NWR was allocated 50% of the waterfowl objectives included in their buffer because their 2004 Biological Review indicated it likely provided up to 60% of the foraging resources for waterfowl locally. Similarly, West Tennessee Complex NWRs were assigned 50% shares (maximum allowed) because of earlier documentation that state and federal lands in the region should provide 90% of foraging resources for waterfowl (Johnson and Orr 2002).

Although estimates of natural flooding were available in some geographies to help inform this share decision (e.g., Lower Mississippi Valley Joint Venture), these data were not available region-wide to empirically estimate the share proportion. If these data become available in the future through partnership-driven efforts, they would improve this process. Presently, the NWR share includes resources supplied through natural flooding and in managed wetlands (i.e., impoundments) within the NWR boundary. Thus, the food resources provided though natural flooding on NWRs, with respect to waterfowl migration chronology, should be considered before translating energy objectives to habitat objectives for each NWR.

In order to evaluate the new objectives, we obtained current waterfowl objectives from CCPs, HMPs, or other sources for comparison. In some cases, waterfowl objectives were expressed as acreage goals of certain wetland management practices (e.g., moist-soil, agriculture; 18% of NWRs), and we used energy estimates from Gray et al. (2013) and other sources to convert these habitat objectives to waterfowl energy objectives for comparison (Table 1; Hagy 2021). In most cases, no explicit waterfowl objectives were available for NWRs (57% of NWRs) with potential waterfowl habitat resources.

As a result of this analysis, each NWR was allocated both population and energy objectives through the step-down process. Population objectives were expressed as abundances by guild. Energy objectives were expressed as generic waterfowl energy days by guild using 300 kcal/day as the energy constant. We used correction factors based on general body mass to adjust diving duck (0.75x), dabbling duck (1x), goose (3x), swan (5x), and crane (4x) energy days to generic WEDs. Constants were created based on approximate body mass and allometric methods in Miller and Eadie (2006). Using a generic energy metric simplifies the translation

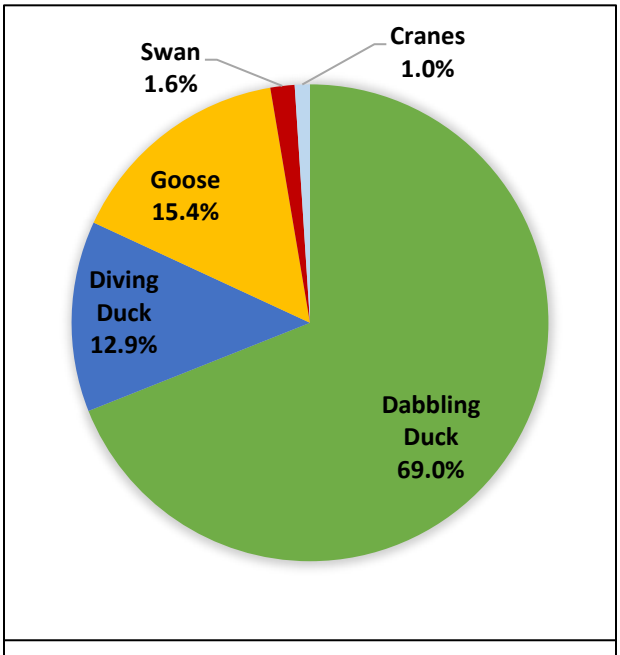


Figure 5. Proportion of total objectives converted to waterfowl energy days on National Wildlife Refuges across the Southeast by waterfowl guild.

of energy objectives to habitat objectives instead of having guild-specific metrics (e.g., goose energy days, duck energy days, crane energy days) that vary by geography (Hagy et al. 2020). Moreover, using a generic and standardized energy metric allows more direct comparisons among geographies instead of each geography developing their own "duck energy day" (e.g., Reinecke and Uihlein 2006, Stafford et al. 2011, Brasher et al. 2018).

Lastly, we assembled acreages of wetlands and upland crop fields managed to provide waterfowl forage from a variety of data sources in order to build a model to estimate energetic carrying capacity for waterfowl on NWRs. We modified wetland classification data from the National Wetland Inventory to estimate coverage of natural wetlands. We used data from Hagy et al. (2019) and workshops with NWRs to estimate acreages and cover types in managed wetlands and croplands on NWRs. We combined acreages of these natural and managed wetlands and multiplied by published energy constants to estimate energetic carrying capacity for each NWR for waterfowl (Hagy 2021). We included constants to adjust estimates for availability (i.e., a portion of the area inaccessible to foraging due to water or vegetation conditions) based on best professional judgment (Table 1).

Results and Discussion

We originally included 112 NWRs in the Southeast (85%) in our analysis because of their establishing language, purposes, or management goals that included migratory birds or waterfowl (Hagy et al. 2020). Following a series of workshops with staff from each NWR complex and local partners, we determined that 76 (58%) NWRs in the Southeast considered migrating and wintering waterfowl a priority resource of concern. The average share (i.e., proportion of resources within the surrounding landscape each NWR chose as their goal) selected across NWRs for dabbling ducks was 33%, followed by 32% for swans, 31% for cranes, 26% for diving ducks, and 22% for geese.

Seventy-six NWRs in the Southeast adopted cumulative objectives of 6.4 million waterfowl during migration and winter, including 4.7 million dabbling ducks, 1.2 million diving ducks, 0.5 million geese, and 50,000 swans and cranes. These objectives totaled more than ~475 million waterfowl energy days on NWRs in the Southeast Region (range = 0.2–46 million energy days / NWR; Appendix A). Objectives for dabbling ducks comprised the majority of waterfowl energy days (69%), followed by diving ducks (13%), geese (15%), swans (2%), and sandhill cranes (1%; Fig. 5). Overall, revised waterfowl objectives for NWRs were 35% greater than current objectives available at NWRs where CCPs and HMPs provided sufficient detail for a comparison (n = 60 NWRs).

Cumulative population and energy objectives were greatest for NWRs located in the Lower Mississippi Valley Joint Venture geographic region (58%, 56%), followed by the Atlantic Coast (14%, 14%), Central Hardwoods (12%, 13%), Gulf Coast (11%, 12%), and East Gulf Coastal Plain (4%, 5%) Joint Venture geographic areas (Appendix B).

Overall, NWRs where wintering and migrating waterfowl were a priority resource of concern in the Southeast provided ~475 million WED. Nearly 47% of energy came from crops and 53% came from natural wetlands. Across the Southeast, current energy objectives exceed current energy production by 140 million WEDs. Only 13 of 60 NWRs currently meet or exceed their energy production goals (Appendix C).

Conclusions

Despite a number of uncertainties in the modeling process, this effort represents the largest scale project of its kind to step-down objectives from an international conservation plan to individual management units across a large geographic region. Adoption of these objectives by NWRs will improve continental waterfowl conservation benefitting both waterfowl populations and consumptive and non-consumptive users who value them. Although Appendix A lists specific numerical population and energy objectives, each NWR will need to incorporate these and translate them into management objectives for their NWR. Appendix D provides a template by which NWRs can easily translate these objectives into HMPs, CCPs, IMPs, and other planning documents. We suggest these objectives (Appendix A) be updated periodically (e.g., 5–10 year intervals) using updated harvest data and the latest science to refine or change the model to improve accuracy and reduce uncertainty.

A number of key assumptions and decision points were used in this analysis that could be verified as additional information becomes available. In particular, the assumptions regarding NWR share allocations, size of the buffer used to aggregate county-level population objectives, and scale at which objectives should be expressed and apportioned (i.e., NWR, administrative complex, biological grouping) are important and can dramatically affect resulting objectives. Additionally, our analysis does not include a step for incorporating needs of individual species of concern (e.g., mottled duck, Mississippi sandhill crane) and larger scale conservation planning objectives. For example, the Lower Mississippi Valley Joint Venture estimates a substantial energy deficit in the Mississippi Alluvial Valley of Arkansas, and NWRs may have a particularly important role to play in addressing that shortfall (USFWS 2015). Where state- or regional-level waterfowl conservation objectives exist independent of this process, additional work with partners is needed to coordinate conservation efforts.

Several efforts to improve wetland coverage and classification models within (Lennon 2021, Martin 2022) and outside of NWRs across the Southeast are ongoing and will help NWRs refine their energetic carrying capacity estimates in the near future (Appendix C). However, large energy deficits likely exist around some of our NWRs when waterfowl populations are high and weather conditions in mid-latitude regions push most waterfowl into our region. Identifying major differences in current food provision and objectives will help NWRs modify or refine management practices to better meet the needs of waterfowl and maximize their contribution to NAWMP. In some cases, only minor changes will be needed to management practices to meet the new objectives. However, significant changes to management practices or land acquisition may be needed in some instances for NWRs to meet their objectives.

Additionally, we recognize that waterfowl energy objectives must be translated to habitat objectives for implementation on NWRs. We believe that the most appropriate scale at which to translate energy objectives to habitat objectives is at the local NWR scale. For example, staff from a NWR could use current and projected capacity to determine the mix of habitat resources needed to meet a hypothetical goal of 7.7 million dabbling duck energy days. Hypothetically, NWR staff could determine that the maximum available floodable area was 200 acres for moist-soil management and 1,200 acres of bottomland forest with a 30% oak component. These resources would provide 600,000 waterfowl energy days and an additional 216 acres of unharvested corn or 520 acres of grain sorghum would be needed to meet the objectives of 7.7 million dabbling duck energy days (Table 1). However, acquisition of an adjacent tract that could provide an additional 500 acres of managed moist-soil vegetation would reduce the need for unharvested corn to 190 acres. Having a mix of habitat resources for waterfowl during migration and winter is a best management practice on NWRs (Pearse et al. 2012), and decisions about habitat objectives should be made at the local level using revised objectives from our analyses (Appendix D).

Habitat objectives should be determined for each taxon according to feeding habits and species composition typically occurring within each NWR buffer. For example, some portion of the energy requirements diving ducks may be met using moist-soil vegetation, but most of the diving duck habitat objectives should likely be met through provision of deep-water marsh where they more commonly occur and feed (Table 3). In cases where diving ducks comprise a significant portion of objectives, shallow-water strategies such as flooded crops or moist-soil management may be inappropriate. Thus, habitat objectives should be carefully apportioned by resource type (i.e., moist soil, bottomland forest, etc.) and guild abundance to maximize habitat delivery for all species, appropriately (Appendix D). Practices that benefit a wide range of wetland-dependent species (e.g., semi-permanent emergent marsh) should be encouraged as part of a diverse wetland complex to meet the foraging needs of waterfowl while also providing habitat resources for a diversity of species (McClain et al. 2019).

Lastly, meeting objectives may be more cost efficient and practical using collective resources within an administrative NWR complex. For example, allocating some portion of objectives where food production capacity is currently low (e.g., Hillside NWR) to a nearby NWR where food production capacity is greater (e.g., Panther Swamp NWR) may be a practical solution to infrastructure, equipment, or staffing challenges at some NWRs. Ultimately, NWR managers and regional administrators must decide on specific strategies to meet their objectives.

Acknowledgements

This document is a product of the U.S. Fish and Wildlife Service, Region 4 (Southeast) National Wildlife Refuge System, Waterfowl Working Group and addresses Action Items 2.1 and 2.2 of the Strategic Action Plan for Waterfowl Management in the Southeast. A large number of U.S. Fish and Wildlife Service staff, including members of the Waterfowl Habitat and Science Teams, Inventory and Monitoring Branch, and other NWR staff provided valuable input. Special thanks

to Dr. Doug Osborne and Lindsay Carlson from the University of Arkansas-Monticello for analysis of banding data. We especially thank C. Hunter, D. Richardson, R. Wheat, B. Crawford, R. Cook, and T. Littrell for providing input on the modeling process during development. We thank the NAWMP National Science Support Team, in particular Kathy Fleming and Mike Brasher, for providing data used in Fleming et al. (2017, 2019) and answering numerous questions about harvest data. We thank J. Von Bank, K. Spragens, and M. Petrie for valuable input on goose population data and analyses. Members of the Gulf Coast and Lower Mississippi Valley Joint Venture partnerships also provided valuable input during model development.

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Table 1. Energy supply constants expressed as waterfowl energy days (WED/ac; 300 kcal/day) and example availability constants (Avail) used to index proportional food availability for high, medium, and low quality wetland conditions for waterfowl on NWRs in the Southeast. Constants include weighted average energy values (seeds and tubers, plant biomass, and invertebrates) from published studies and theses compiled in the Integrated Waterbird Management and Monitoring protocol revision (Loges et al. 2021) and archived in ServCat (https://ecos.fws.gov/ServCat/Reference/Profile/135190).

	Wetland Habitat Resource Type	Avail	Waterfowl Energy (WED/ac)		
			High	Mod	Low
Natural Wetlands	Semi-permanent Wooded	50%	300	200	100
	Seasonal Wooded	25%	300	200	100
	Seasonal Emergent	90%	2,500	1,800	1,000
	Semi-permanent Emergent	50%	1,000	700	400
	Brackish Emergent	25%	900	500	200
	Aquatic Bed	50%	3,000	1,600	800
	Open Water	50%	6	3	1
	Riverine	75%	6	3	1
	Mudflat	75%	200	100	50
Cropland	Unharvested Rice	95%	35,000	25,000	14,000
	Unharvested Grain Sorghum	95%	20,000	15,000	9,000
	Unharvested Corn	95%	43,000	33,000	22,000
	Unharvested Soybean	95%	12,000	9,600	7,000
	Unharvested Millet	95%	8,000	5,000	2,000
	Green Browse	50%	3,000	1,900	1,000
	Harvested Crops	95%	800	500	200

Table 2. The proportion of objectives within the 50-km buffer around each NWR for each guild that will be adopted by the NWR for provisioning (i.e., NWR share).

Complex	National Wildlife Refuge	Dabbling Ducks	Diving Ducks	Geese	Swan	Cranes
Alabama	Eufaula NWR	40%	25%	20%	30%	30%
	Wheeler NWR	40%	20%	40%	0%	75%
Carolina Sandhills	Pee Dee NWR	40%	40%	20%	30%	30%
Central Arkansas	Bald Knob NWR	40%	25%	15%	30%	30%
	Big Lake NWR	30%	40%	5%	30%	30%
	Cache River NWR	30%	25%	5%	30%	30%
	Holla Bend NWR	30%	30%	15%	30%	30%
	Wapanocca NWR	30%	40%	5%	30%	30%
Central Louisiana	Catahoula NWR	30%	40%	20%	30%	30%
	Grand Cote NWR	40%	30%	20%	30%	30%
	Lake Ophelia NWR	40%	30%	20%	30%	30%
Clarks River	Clarks River NWR	30%	20%	20%	30%	30%
	Green River NWR	50%	30%	30%	30%	30%
Gulf Coast	Grand Bay NWR	30%	30%	30%	30%	30%
Loxahatchee	Loxahatchee NWR	20%	20%	20%	20%	50%
Merritt Island	Lake Woodruff NWR	20%	20%	20%	20%	20%
	Merritt Island NWR	40%	30%	30%	30%	30%
North Carolina Coastal	Alligator River NWR	40%	10%	30%	35%	30%
	Cedar Island NWR	20%	10%	10%	10%	30%
	Currituck NWR	30%	10%	10%	30%	10%
	Great Dismal Swamp NWR	30%	10%	30%	50%	30%
	Mackay Island NWR	50%	10%	50%	100%	30%
	Mattamuskeet NWR	50%	20%	50%	50%	30%
	Pea Island NWR	50%	10%	50%	100%	30%
	Pocosin Lakes NWR	50%	10%	50%	50%	30%
	Roanoke River NWR	30%	10%	30%	10%	10%
	Swanquarter NWR	30%	20%	10%	20%	30%
North Florida	St. Marks NWR	30%	10%	0%	0%	0%
North Louisiana	Black Bayou Lake NWR	30%	30%	5%	30%	30%
	D'Arbonne NWR	30%	40%	5%	30%	30%
	Handy Brake NWR	30%	40%	5%	30%	30%
	Red River NWR	25%	25%	30%	30%	30%
	Upper Ouachita NWR	30%	40%	30%	30%	30%
North Mississippi	Coldwater River NWR	20%	20%	20%	30%	30%
	Dahomey NWR	40%	40%	20%	30%	30%
	Tallahatchie NWR	30%	30%	20%	30%	30%
Noxubee	Choctaw NWR	20%	20%	10%	30%	30%
	Noxubee NWR	30%	30%	10%	30%	30%
Piedmont	Bond Swamp NWR	20%	20%	5%	10%	10%

Table 2. Continued.

Complex	National Wildlife Refuge	Dabbling Ducks	Diving Ducks	Geese	Swan	Cranes
Savannah Coastal	Savannah NWR	35%	25%	5%	30%	30%
	Atchafalaya NWR	10%	10%	10%	30%	30%
	Bayou Sauvage NWR	15%	15%	5%	30%	30%
	Big Branch Marsh NWR	15%	15%	5%	30%	30%
Southeast Louisiana	Breton NWR	5%	30%	5%	30%	30%
	Cat Island NWR	10%	10%	10%	30%	30%
	Delta NWR	40%	40%	40%	30%	30%
	Mandalay NWR	5%	5%	5%	30%	30%
	Felsenthal NWR	40%	40%	5%	33%	33%
South Arkansas	Overflow NWR	33%	33%	10%	33%	33%
	Pond Creek NWR	20%	5%	5%	5%	5%
	Ace Basin NWR	30%	20%	30%	30%	30%
South Carolina Low Country	Cape Romain NWR	20%	30%	5%	30%	30%
	Santee NWR	35%	15%	30%	30%	30%
	Waccamaw NWR	30%	20%	5%	30%	30%
	Cameron Prairie NWR	15%	15%	5%	20%	20%
Southwest Louisiana	Lacassine NWR	20%	20%	5%	20%	20%
	Sabine NWR	20%	20%	5%	20%	20%
Tennessee River	Cross Creeks NWR	50%	40%	50%	50%	50%
	Tennessee NWR	50%	40%	50%	50%	50%
Tensas River	Tensas River NWR	20%	20%	10%	30%	30%
	Bayou Cocodrie NWR	30%	30%	30%	30%	30%
	Hillside NWR	40%	20%	30%	30%	30%
	Holt Collier NWR	30%	10%	10%	30%	30%
	Mathews Brake NWR	40%	20%	25%	30%	30%
Theodore Roosevelt	Morgan Brake NWR	40%	20%	35%	30%	30%
	Panther Swamp NWR	40%	20%	30%	30%	30%
	St. Catherine Creek NWR	30%	30%	30%	30%	30%
	Theodore Roosevelt NWR	20%	10%	10%	30%	30%
	Yazoo NWR	30%	20%	20%	30%	30%
	Chickasaw NWR	45%	45%	50%	30%	30%
	Hatchie NWR	50%	50%	20%	30%	30%
West Tennessee	Lake Isom NWR	45%	45%	30%	30%	30%
	Lower Hatchie NWR	45%	45%	35%	30%	30%
	Reelfoot NWR	50%	50%	30%	30%	30%
White River	White River NWR	33%	33%	10%	33%	33%

Table 3. Example foraging preferences (i.e., percent of forage requirements available within each resource type, 0–100%) of waterfowl taxa among habitat resource types in two different geographies in the southeastern United States that can be used to apportion habitat objectives subsequently stepped down from these energy and population objectives for individual taxa, species, and management units.

Geographic Area	Taxon	Seasonal emergent	Deepwater Marsh / Aquatic Bed	Forested / Scrub-shrub	Green Browse / Harvested Cropland	Unharvested Cropland
Mississippi	Dabbling ducks	50%	30%	100%	5%	60%
	Diving ducks	25%	70%	0%	0%	10%
	Geese	20%	0%	0%	90%	25%
	Swans / Cranes	5%	0%	0%	5%	5%
Atlantic	Dabbling ducks	50%	20%	100%	0%	35%
	Diving ducks	20%	60%	0%	0%	35%
	Geese	10%	0%	0%	50%	10%
	Swans / Cranes	20%	20%	0%	50%	20%

Appendix A. Final waterfowl population and energy (waterfowl energy days; 300 kcal/day) objectives for National Wildlife Refuges in the Southeast. Objectives were finalized during workshops with staff from each NWR during 2019–2022 in which local staff and partners provided input on NWR management share, migration curves, and other model parameters based on available information and best professional opinion.

Complex	National Wildlife Refuge	Population Objectives					Energy Objectives					
		Dabbling Duck	Diving Duck	Goose	Swan	Crane	Dabbling Duck	Diving Duck	Goose	Swan	Crane	Total
Alabama	Cahaba River	-	-	-	-	-	-	-	-	-	-	-
	Eufaula	28,202	4,677	1,468	0	45	1,552,463	179,313	261,026	0	0	1,992,802
	Fern Cave	-	-	-	-	-	-	-	-	-	-	-
	Key Cave NWR	-	-	-	-	-	-	-	-	-	-	-
	Mountain Longleaf	-	-	-	-	-	-	-	-	-	-	-
	Paint Rock	-	-	-	-	-	-	-	-	-	-	-
	Saunta Cave	-	-	-	-	-	-	-	-	-	-	-
	Watercress Darter	-	-	-	-	-	-	-	-	-	-	-
	Wheeler	115,113	42,081	8,893	0	22,777	6,522,940	2,214,200	1,591,702	0	4,867,746	15,196,588
Caribbean Islands	Buck Island	-	-	-	-	-	-	-	-	-	-	-
	Cabo Rojo	-	-	-	-	-	-	-	-	-	-	-
	Culebra	-	-	-	-	-	-	-	-	-	-	-
	Desecheo	-	-	-	-	-	-	-	-	-	-	-
	Green Cay	-	-	-	-	-	-	-	-	-	-	-
	Laguna Cartagena	-	-	-	-	-	-	-	-	-	-	-
	Navassa Island	-	-	-	-	-	-	-	-	-	-	-
	Sandy Point	-	-	-	-	-	-	-	-	-	-	-
	Vieques	-	-	-	-	-	-	-	-	-	-	-
Carolina Sandhills	Carolina Sandhills	-	-	-	-	-	-	-	-	-	-	-
	Pee Dee	26,345	9,493	1,428	1	0	1,789,215	490,496	261,426	0	0	2,541,137
Central Arkansas	Bald Knob	210,610	15,901	33,722	1	1	13,516,762	747,949	4,744,077	0	0	19,008,788
	Big Lake	86,134	6,463	9,015	0	0	5,395,426	266,849	1,589,191	0	0	7,251,466
	Cache River	567,234	49,369	46,753	0	1	35,531,602	2,319,382	8,241,847	0	0	46,092,832
	Holla Bend	71,949	9,996	1,630	0	0	4,506,872	414,397	286,642	0	0	5,207,911
	Logan Cave	-	-	-	-	-	-	-	-	-	-	-
	Wapanocca	101,271	10,018	9,651	0	1	6,343,656	413,627	1,697,041	0	0	8,454,324

Appendix A. Continued.

Complex	National Wildlife Refuge	Population Objectives					Energy Objectives					
		Dabbling Duck	**Diving Duck**	**Goose**	**Swan**	**Crane**	**Dabbling Duck**	**Diving Duck**	**Goose**	**Swan**	**Crane**	**Total**
Central Louisiana	Catahoula	45,513	17,650	257	0	1	2,749,201	698,525	0	0	0	3,447,726
	Grand Cote	171,491	22,993	3,486	0	27	10,358,755	909,948	498,749	0	0	11,767,452
	Lake Ophelia	73,053	12,612	1,095	0	5	4,412,707	499,138	156,627	0	0	5,068,472
Clarks River	Clarks River	71,801	23,438	5,783	0	5	5,147,784	1,247,380	976,590	0	0	7,371,753
	Green River	50,274	3,451	8,458	23	8	3,604,409	183,845	1,428,491	0	0	5,216,746
Crystal River	Chassahowitzka	-	-	-	-	-	-	-	-	-	-	-
	Crystal River	-	-	-	-	-	-	-	-	-	-	-
	Egmont Key	-	-	-	-	-	-	-	-	-	-	-
	Passage Key	-	-	-	-	-	-	-	-	-	-	-
	Pinellas	-	-	-	-	-	-	-	-	-	-	-
Ding Darling	Caloosahatchee	-	-	-	-	-	-	-	-	-	-	-
	Ding Darling	-	-	-	-	-	-	-	-	-	-	-
	Island Bay	-	-	-	-	-	-	-	-	-	-	-
	Matlacha Pass	-	-	-	-	-	-	-	-	-	-	-
	Pine Island	-	-	-	-	-	-	-	-	-	-	-
Everglades Headwaters	Archie Carr	-	-	-	-	-	-	-	-	-	-	-
	Everglades Headw.	-	-	-	-	-	-	-	-	-	-	-
	Lake Wales Ridge	-	-	-	-	-	-	-	-	-	-	-
	Pelican Island	-	-	-	-	-	-	-	-	-	-	-
Florida Keys	Crocodile Lake	-	-	-	-	-	-	-	-	-	-	-
	Great White Heron	-	-	-	-	-	-	-	-	-	-	-
	Key West	-	-	-	-	-	-	-	-	-	-	-
	National Key Deer	-	-	-	-	-	-	-	-	-	-	-
Florida Panther	Florida Panther	-	-	-	-	-	-	-	-	-	-	-
	Ten Thousand Island	-	-	-	-	-	-	-	-	-	-	-

Appendix A. Continued.

Complex	National Wildlife Refuge	Population Objectives					Energy Objectives					
		Dabbling Duck	Diving Duck	Goose	Swan	Crane	Dabbling Duck	Diving Duck	Goose	Swan	Crane	Total
Gulf Coast	Bon Secour	-	-	-	-	-	-	-	-	-	-	-
	Grand Bay	9,918	5,611	94	0	13	761,489	281,575	0	0	0	1,043,064
	MS Sandhill Crane	-	-	-	-	-	-	-	-	-	-	-
Loxahatchee	Hobe Sound	-	-	-	-	-	-	-	-	-	-	-
	Loxahatchee	11,541	17,641	0	0	37	1,011,130	1,134,792	0	0	0	2,145,922
Merritt Island	Lake Woodruff	1,835	6,538	478	0	86	160,803	420,575	0	0	0	581,378
	Merritt Island	27,673	49,917	0	0	130	2,424,461	3,210,955	0	0	0	5,635,416
	St. Johns	-	-	-	-	-	-	-	-	-	-	-
North Carolina Coastal	Alligator River	36,860	17,101	6,771	5,693	0	2,880,811	1,060,121	737,829	1,615,004	0	6,293,766
	Cedar Island	5,473	30,887	647	22	0	436,176	1,598,934	70,471	0	0	2,105,581
	Currituck	2,054	1,717	228	37	0	163,677	88,878	0	0	0	252,555
	Mackay Island	13,020	6,355	4,145	1,270	0	1,037,563	328,974	451,747	360,345	0	2,178,629
	Mattamuskeet	62,015	65,448	8,495	11,708	0	4,942,071	3,388,058	925,736	3,321,425	0	12,577,291
	Pea Island	15,323	19,514	796	1,456	0	1,020,798	959,695	170,329	392,396	0	2,543,219
	Pocosin Lakes	41,988	18,743	7,999	7,386	0	3,346,122	970,247	871,651	2,095,357	0	7,283,377
	Roanoke River	20,080	4,728	6,840	246	1	1,600,217	244,761	745,381	0	0	2,590,359
	Swanquarter	7,612	33,562	247	328	0	606,618	1,737,406	0	92,912	0	2,436,936
North Florida	Cedar Keys	-	-	-	-	-	-	-	-	-	-	-
	Lower Suwannee	-	-	-	-	-	-	-	-	-	-	-
	St. Marks	6,600	9,674	0	0	0	507,698	505,201	0	0	0	1,012,899
	St. Vincent	-	-	-	-	-	-	-	-	-	-	-
North Louisiana	Black Bayou Lake	2,959	485	56	0	0	180,489	0	0	0	0	180,489
	D'Arbonne	26,300	6,387	310	0	2	1,604,113	274,809	0	0	0	1,878,922
	Handy Brake	10,624	1,963	188	0	0	647,972	84,457	0	0	0	732,429
	Red River	95,342	32,986	8,203	0	15	5,759,027	1,419,245	1,173,758	0	0	8,352,030
	Tensas River	53,654	3,799	2,747	0	3	3,272,539	163,460	382,705	0	0	3,818,703
	Upper Ouachita	95,612	17,667	10,137	0	16	5,831,742	760,115	1,412,432	0	0	8,004,289

Appendix A. Continued.

Complex	National Wildlife Refuge	Population Objectives					Energy Objectives					
		Dabbling Duck	**Diving Duck**	**Goose**	**Swan**	**Crane**	**Dabbling Duck**	**Diving Duck**	**Goose**	**Swan**	**Crane**	**Total**
North Mississippi	Coldwater River	81,990	7,964	16,150	1	154	6,453,648	413,516	2,624,443	0	0	9,491,607
	Dahomey	13,233	1,435	3,636	0	0	1,041,615	74,497	590,789	0	0	1,706,901
	Tallahatchie	87,246	9,542	10,618	0	23	6,867,377	495,463	1,725,422	0	0	9,088,263
Noxubee	Choctaw	7,240	516	0	0	0	398,542	0	0	0	0	398,542
	Noxubee	32,454	14,120	958	0	11	2,554,571	733,179	155,650	0	0	3,443,399
Okefenokee	Banks Lake	-	-	-	-	-	-	-	-	-	-	-
	Okefenokee	-	-	-	-	-	-	-	-	-	-	-
Piedmont	Bond Swamp	11,608	5,828	267	0	83	719,914	330,462	0	0	0	1,050,377
	Mountain Bogs	-	-	-	-	-	-	-	-	-	-	-
	Piedmont	-	-	-	-	-	-	-	-	-	-	-
Savannah Coastal	Blackbeard Island	-	-	-	-	-	-	-	-	-	-	-
	Harris Neck	-	-	-	-	-	-	-	-	-	-	-
	Pinckney Island	-	-	-	-	-	-	-	-	-	-	-
	Savannah	14,374	18,380	294	0	0	1,035,074	949,716	0	0	0	1,984,789
	Tybee	-	-	-	-	-	-	-	-	-	-	-
	Wassaw	-	-	-	-	-	-	-	-	-	-	-
	Wolf Island	-	-	-	-	-	-	-	-	-	-	-
South Carolina Low Country	Ace Basin	32,682	13,497	555	176	0	2,353,472	698,119	101,571	0	0	3,153,162
	Cape Romain	22,608	49,430	158	1	0	1,627,986	2,556,796	0	0	0	4,184,781
	Santee	60,895	13,986	1,643	18	300	4,385,097	722,671	300,610	0	69,130	5,477,509
	Waccamaw	35,125	18,972	391	1	0	2,529,352	980,279	0	0	0	3,509,631
Southeast Louisiana	Atchafalaya	27,357	11,026	306	0	1	1,652,498	436,969	0	0	0	2,089,467
	Bayou Sauvage	70,417	45,038	435	0	0	6,356,099	2,262,464	0	0	0	8,618,562
	Bayou Teche	-	-	-	-	-	-	-	-	-	-	-
	Big Branch Marsh	39,881	20,266	117	0	0	3,599,793	1,018,070	0	0	0	4,617,863
	Bogue Chitto	-	-	-	-	-	-	-	-	-	-	-
	Breton	1,029	3,662	24	0	0	92,903	183,957	0	0	0	276,860
	Cat Island	4,061	1,652	30	0	0	245,292	65,380	0	0	0	310,673

Appendix A. Continued.

Complex	National Wildlife Refuge	Population Objectives					Energy Objectives					
		Dabbling Duck	**Diving Duck**	**Goose**	**Swan**	**Crane**	**Dabbling Duck**	**Diving Duck**	**Goose**	**Swan**	**Crane**	**Total**
Southeast Louisiana	Delta	103,851	46,873	6,031	0	0	9,373,918	2,352,054	859,167	0	0	12,585,139
	Mandalay	22,093	24,738	74	0	0	1,994,139	1,239,960	0	0	0	3,234,098
South Arkansas	Felsenthal	54,342	6,446	336	0	4	3,314,528	277,343	0	0	0	3,591,870
	Overflow	50,375	4,497	2,900	0	8	3,291,950	194,229	450,234	0	0	3,936,413
	Pond Creek	39,779	940	311	0	0	2,426,265	0	0	0	0	2,426,265
Southwest Louisiana	Cameron Prairie	33,714	7,990	6,435	0	74	2,461,799	449,923	916,818	0	0	3,828,540
	Lacassine	108,052	28,108	17,942	0	85	9,753,116	1,582,825	2,556,122	0	0	13,892,062
	Sabine	79,303	18,628	7,920	0	213	5,790,802	1,049,012	1,128,290	0	0	7,968,104
	Shell Keys	-	-	-	-	-	-	-	-	-	-	-
Tennessee River	Cross Creeks	110,402	41,888	4,904	9	33	8,863,897	2,180,700	921,434	0	0	11,966,030
	Big Sandy Unit	62,976	23,638	2,315	3	9	5,056,198	1,231,942	434,938	0	0	6,723,078
	Busseltown Unit	14,413	3,449	1,063	1	3	1,157,164	179,774	199,798	0	0	1,536,735
	Duck River Unit	118,759	37,023	9,016	13	11	9,534,847	1,929,512	1,694,067	0	0	13,158,427
	Tennessee - Overall	196,148	64,111	12,394	18	24	15,748,209	3,341,228	2,328,803	0	0	21,418,239
Theodore Roosevelt	Bayou Cocodrie	20,976	4,674	152	0	0	1,267,059	185,235	0	0	0	1,452,294
	Hillside	8,666	1,335	1,054	0	0	682,150	69,317	171,238	0	0	922,705
	Holt Collier	2,139	190	256	0	0	168,384	0	0	0	0	168,384
	Mathews Brake	2,633	263	487	0	0	208,975	0	0	0	0	208,975
	Morgan Brake	58,939	7,916	10,634	0	0	4,677,264	411,041	1,728,116	0	0	6,816,421
	Panther Swamp	106,048	15,541	10,794	0	0	8,415,742	806,969	1,754,058	0	0	10,976,769
	St. Catherine Creek	34,926	3,368	424	0	0	2,109,664	133,307	0	0	0	2,242,971
	Theodore Roosevelt	2,819	411	190	0	0	221,904	0	0	0	0	221,904
	Yazoo	46,114	8,488	8,206	0	1	3,629,774	440,746	1,333,452	0	0	5,403,972
West Tennessee	Chickasaw	122,709	15,262	31,112	1	16	8,905,401	794,575	5,845,828	0	0	15,545,804
	Hatchie	54,550	2,540	1,332	0	3	3,958,852	132,400	250,248	0	0	4,341,500
	Lake Isom	72,788	10,724	6,835	2	70	5,282,444	558,877	1,284,243	0	0	7,125,564

Appendix A. Continued.

Complex	National Wildlife Refuge	Population Objectives					Energy Objectives					
		Dabbling Duck	**Diving Duck**	**Goose**	**Swan**	**Crane**	**Dabbling Duck**	**Diving Duck**	**Goose**	**Swan**	**Crane**	**Total**
West Tennessee	Chickasaw	122,709	15,262	31,112	1	16	8,905,401	794,575	5,845,828	0	0	15,545,804
	Hatchie	54,550	2,540	1,332	0	3	3,958,852	132,400	250,248	0	0	4,341,500
	Lake Isom	72,788	10,724	6,835	2	70	5,282,444	558,877	1,284,243	0	0	7,125,564
	Lower Hatchie	87,349	9,403	21,779	1	2	6,339,189	486,912	4,092,080	0	0	10,918,181
	Reelfoot	179,418	23,587	15,083	4	138	13,020,911	1,227,960	2,834,058	0	0	17,082,929
White River	White River	405,074	33,630	61,647	0	2	25,373,886	1,388,596	10,840,027	0	0	37,602,509

(-) Wintering and migrating waterfowl are not a priority resource of concern at this NWR.

Appendix B. Final waterfowl (A) population and (B) energy objectives (waterfowl energy days; 300 kcal/day) for National Wildlife Refuges in the Southeast by migratory bird Joint Venture geography and state within each geogrpahy.

A. Population Objectives

Joint Venture / State	Dabbling Duck	Diving Duck	Goose	Swan	Cranes	Total
Atlantic Coast	**449,111**	**401,737**	**41,382**	**28,343**	**638**	**921,210**
FL	41,050	74,096	478	0	253	115,877
GA	11,608	5,828	267	0	83	17,786
NC	230,770	207,549	37,596	28,146	2	504,063
SC	165,683	114,264	3,041	196	300	283,484
Central Hardwoods	**543,739**	**174,969**	**40,432**	**50**	**22,846**	**782,036**
AL	115,113	42,081	8,893	0	22,777	188,864
KY	122,075	26,888	14,241	23	13	163,240
TN	306,551	105,999	17,298	27	57	429,931
East Gulf Coastal Plain	**216,435**	**41,530**	**25,536**	**1**	**61**	**283,564**
AL	35,442	5,193	1,468	0	45	42,149
FL	6,639	10,274	0	0	0	16,913
MS	32,454	14,120	958	0	11	47,543
TN	141,899	11,943	23,110	1	5	176,959
Gulf Coast	**468,258**	**200,915**	**39,071**	**0**	**386**	**708,630**
LA	458,340	195,303	38,977	0	372	692,993
MS	9,918	5,611	94	0	13	15,637
Lower Mississippi Valley	**3,033,378**	**377,181**	**308,410**	**9**	**493**	**3,719,470**
AR	1,586,767	137,260	165,965	2	18	1,890,012
LA	601,905	127,568	26,785	0	71	756,329
MS	469,791	62,780	62,630	1	179	595,380
TN	374,915	49,573	53,030	7	224	477,750
Total	**4,710,920**	**1,196,332**	**454,832**	**28,404**	**24,423**	**6,414,910**

B. Energy Objectives

Joint Venture / State	Dabbling Duck	Diving Duck	Goose	Swan	Cranes	Total
Atlantic Coast	**34,070,557**	**21,871,934**	**4,636,754**	**7,877,440**	**69,130**	**68,525,814**
FL	3,596,394	4,766,322	0	0	0	8,362,716
GA	719,914	330,462	0	0	0	1,050,377
NC	17,823,267	10,867,570	4,234,572	7,877,440	0	40,802,849
SC	11,930,981	5,907,580	402,181	0	69,130	18,309,872
Central Hardwoods	**39,887,238**	**9,167,352**	**7,247,020**	**0**	**4,867,746**	**61,169,356**
AL	6,522,940	2,214,200	1,591,702	0	4,867,746	15,196,588
KY	8,752,193	1,431,225	2,405,081	0	0	12,588,499
TN	24,612,106	5,521,927	3,250,237	0	0	33,384,270
East Gulf Coastal Plain	**15,311,314**	**2,037,005**	**4,759,004**	**0**	**0**	**22,107,323**
AL	1,951,005	179,313	261,026	0	0	2,391,344
FL	507,698	505,201	0	0	0	1,012,899
MS	2,554,571	733,179	155,650	0	0	3,443,399
TN	10,298,041	619,312	4,342,328	0	0	15,259,681
Gulf Coast	**40,184,058**	**10,419,840**	**5,460,397**	**0**	**0**	**56,064,295**
LA	39,422,568	10,138,265	5,460,397	0	0	55,021,231
MS	761,489	281,575	0	0	0	1,043,064
Lower Mississippi Valley	**199,367,593**	**16,945,922**	**51,364,977**	**0**	**0**	**267,678,492**
AR	99,700,947	6,022,372	27,849,059	0	0	133,572,378
LA	36,469,043	5,246,666	3,624,270	0	0	45,339,979
MS	35,988,847	3,095,471	9,927,519	0	0	49,011,837
TN	27,208,756	2,581,412	9,964,129	0	0	39,754,297
Total	**328,820,760**	**60,442,053**	**73,468,152**	**7,877,440**	**4,936,876**	**475,545,280**

Appendix C.

Table A. Approximate acreages (mean planned during 2016–2021) of wetlands and croplands on National Wildlife Refuges in the Southeast where wintering waterfowl are a priority resource of concern.

National Wildlife Refuge	Forested	Managed Moist-soil	Freshwater Emergent	Brackish Emergent	Aquatic Bed / SAV	Open Water	Rice[1]	Milo[1]	Corn[1]	Other[2]	Harvested Crops
Ace Basin NWR	2,081	1,000	3,700	3,948	84	653	0	0	0	0	0
Alligator River NWR	116,213	400	5,673	12,592	100	1,787	100	0	0	96	1,984
Atchafalaya NWR	14,986	100	70	0	87	133	0	0	0	40	0
Bald Knob NWR	2,886	1,500	500	0	51	182	700	0	0	0	2,296
Bayou Cocodrie NWR	12,720	180	150	0	74	179	0	0	0	70	0
Bayou Sauvage NWR	1,018	0	11,839	13,650	0	0	0	0	0	0	0
Big Branch Marsh NWR	2,086	0	2,253	9,054	0	0	0	0	0	0	0
Big Lake NWR	6,340	100	600	0	100	3,645	0	0	0	0	0
Black Bayou Lake NWR	1,329	0	340	0	15	837	0	0	0	0	0
Bond Swamp NWR	5,683	0	32	0	9	12	0	0	0	0	0
Breton NWR	0	0	0	700	0	0	0	0	0	0	0
Cache River NWR	39,342	2,300	4,500	0	747	1,326	576	0	0	200	3,000
Cameron Prairie NWR	137	1,871	14,538	7,316	0	0	0	0	0	0	0
Cape Romain NWR	144	0	27	40,000	0	16,000	0	0	0	0	0
Cat Island NWR	10,101	0	100	0	241	350	0	0	0	0	0
Catahoula NWR	14,489	200	716	0	272	1,337	0	0	0	0	0
Cedar Island NWR	2,420	0	267	11,000	1	77	0	0	0	0	0
Chickasaw NWR	19,000	626	50	0	270	1,361	0	0	200	0	450
Choctaw NWR	2,671	55	100	0	900	100	50	0	0	0	0
Clarks River NWR	8,000	50	60	0	13	102	0	20	50	140	340
Coldwater River NWR	1,500	420	600	0	4	21	100	0	0	0	0
Cross Creeks NWR	836	300	350	0	250	2,062	0	0	150	100	700
Currituck NWR	654	0	82	2,000	0	342	0	0	0	0	0
Dahomey NWR	7,969	305	310	0	0	0	0	0	0	0	0
D'Arbonne NWR	11,573	500	1,070	0	124	1,502	0	0	0	0	0
Delta NWR	0	0	49,301	0	0	0	0	0	0	0	0

Appendix C. Table A Continued.

National Wildlife Refuge	Forested	Managed Moist-soil	Freshwater Emergent	Brackish Emergent	Aquatic Bed / SAV	Open Water	Rice[1]	Milo[1]	Corn[1]	Other[2]	Harvested Crops
Eufaula NWR	733	300	1,200	0	500	5,300	0	0	0	0	0
Felsenthal NWR	40,845	0	2,007	0	385	6,560	0	0	0	0	0
Grand Bay NWR	4,880	0	329	3,679	0	0	0	0	0	0	0
Grand Cote NWR	2,683	800	400	0	78	537	0	450	0	0	265
Green River NWR	0	0	0	0		0	0	0	0	0	0
Handy Brake NWR	117	0	3	0	0	230	0	0	0	0	0
Hatchie NWR	9,260	203	174	0	500	46	0	0	165	0	485
Hillside NWR	9,304	400	610	0	108	187	0	0	0	0	0
Holla Bend NWR	421	180	115	0	33	513	0	0	170	0	600
Holt Collier NWR	600	100	200	0	100	16	0	0	0	0	0
Lacassine NWR	173	704	29,638	0	0	0	0	0	0	80	446
Lake Isom NWR	945	530	39	0	158	0	0	0	100	0	350
Lake Ophelia NWR	11,420	350	1,094		162	575	0	500	0	0	1,900
Lake Woodruff NWR	8,079	200	9,660	0	62	674	0	0	0	0	385
Lower Hatchie NWR	11,500	175	136	0	180	563	0	0	150	0	1,150
Loxahatchee NWR	28,548	0	102,695	0	1,000	1,428	0	0	0	0	0
Mackay Island NWR	500	875	3,500	1,500	65	2,000	0	0	0	65	0
Mandalay NWR	182	0	3,623	0	0	0	0	0	0	0	0
Mathews Brake NWR	1,712	0		0	237	286	0	0	0	0	0
Mattamuskeet NWR	2,771	1,997	2,046	0	0	40,000	0	0	0	0	0
Merritt Island NWR	7,000	0	11,500	13,600	500	60,732	0	0	0	0	0
Morgan Brake NWR	2,500	1,450	165	0	300	22	100	0	0	200	0
Noxubee NWR	19,752	300	530	0	42	562	50	0	0	0	0
Overflow NWR	9,096	1,172	70	0	1	0	0	0	0	300	0
Panther Swamp NWR	22,768	600	86	0	500	1,200	350	175	0	175	2,200
Pea Island NWR	0	0	790	1,375	565	20,000	0	0	0	0	0
Pee Dee NWR	2,363	120	36		78	5	0	0	150	0	700
Pocosin Lakes NWR	73,864	280	1,000	100	70	6,648	0	0	250	150	1,000

Appendix C. Table A Continued.

National Wildlife Refuge	Forested	Managed Moist-soil	Freshwater Emergent	Brackish Emergent	Aquatic Bed / SAV	Open Water	Rice[1]	Milo[1]	Corn[1]	Other[2]	Harvested Crops
Pond Creek NWR	16,335	0	665	0	29	387	0	0	0	0	0
Red River NWR	2,390	1,225	3	0	81	184	0	0	0	125	400
Reelfoot NWR	6,525	165	1,054	0	447	979	0	0	200	0	600
Roanoke River NWR	19,397	0	64		6	229	0	0	0	0	0
Sabine NWR	0	0	83,372	39,802	0	0	0	0	0	0	0
Santee NWR	2,791	600	700	0	183	5,439	0	0	0	100	0
Savannah NWR	17,930	0	8,816	685	78	229	0	0	0	0	0
St. Catherine Creek NWR	12,000	900	1,000	0	250	3,000	0	0	0	200	0
St. Marks NWR	23,415	0	3,200	25,000	500	2,165	0	0	0	0	0
Swanquarter NWR	2,602	0	157	3,000	2	15,000	0	0	0	0	0
Tallahatchie NWR	800	166	266	0	100	400	0	0	0	100	0
Tennessee NWR - Overall	2,975	1,460	2,700	0	0	34,300	0	0	450	200	3,050
Big Sandy	250	10	0	0	0	15,400	0	0	50	50	550
Busseltown Unit	400	150	200	0	0	1,900	0	0	100	0	500
Duck River Unit	2,325	1,300	2,500	0	0	17,000	0	0	300	150	2,000
Tensas River NWR - Overall	60,783	459	265	0	174	271	0	150	0	0	0
Theodore Roosevelt NWR	200	0	4	0	0	6	0	0	0	0	0
Upper Ouachita NWR	28,807	500	571	0	370	2,154	200	0	0	375	1,500
Waccamaw NWR	25,947	45	1,539	0	7	190	40	0	0	15	0
Wapanocca NWR	2,300	65	80	0	600	200	0	0	0	114	222
Wheeler NWR	9,836	328	2,558	0	169	8,889	0	0	500	0	2,760
White River NWR	140,039	443	800	0	1,102	6,367	150	0	0	150	0
Yazoo NWR	6,000	300	574	0	432	516	200	0	0	100	1,425
Total	**1,390,126**	**27,788**	**418,403**	**359,396**	**16,143**	**280,583**	**2,616**	**1,295**	**2,535**	**3,090**	**32,518**

[1] Unharvested

[2] Includes winter wheat, other cover crops, millet, and buckwheat

Appendix C.

Table B. Energetic carrying capacities from natural wetlands and croplands and the difference in energy provided versus energy objectives (Δ Energy; Appendix A) in waterfowl energy days on National Wildlife Refuges in the Southeast where wintering waterfowl are a priority resource of concern.

National Wildlife Refuge	Natural Energy	Crop Energy	Total Energy	Δ Energy
Ace Basin NWR	2,854,347	0	2,854,347	(298,815)
Alligator River NWR	2,813,707	1,394,900	4,208,607	(2,085,159)
Atchafalaya NWR	399,634	190,000	589,634	(1,499,832)
Bald Knob NWR	2,795,770	16,046,100	18,841,870	(166,918)
Bayou Cocodrie NWR	709,058	332,500	1,041,558	(410,736)
Bayou Sauvage NWR	7,536,826	0	7,536,826	(1,081,736)
Big Branch Marsh NWR	2,796,749	0	2,796,749	(1,821,114)
Big Lake NWR	668,699	0	668,699	(6,582,767)
Black Bayou Lake NWR	157,283	0	157,283	(23,206)
Bond Swamp NWR	297,139	0	297,139	(753,237)
Breton NWR	142,590	0	142,590	(134,270)
Cache River NWR	6,483,395	14,195,300	20,678,695	(25,414,136)
Cameron Prairie NWR	6,895,965	0	6,895,965	3,067,425
Cape Romain NWR	1,610,237	0	1,610,237	(2,574,545)
Cat Island NWR	417,017	0	417,017	106,344
Catahoula NWR	1,076,041	0	1,076,041	(2,371,685)
Cedar Island NWR	357,135	0	357,135	(1,748,446)
Chickasaw NWR	1,750,791	5,647,525	7,398,316	(8,147,488)
Choctaw NWR	662,071	1,140,000	1,802,071	1,403,529
Clarks River NWR	310,907	2,047,413	2,358,319	(5,013,434)
Coldwater River NWR	908,798	2,280,000	3,188,798	(6,302,809)
Cross Creeks NWR	829,976	7,198,750	8,028,726	(3,937,304)
Currituck NWR	86,519	0	86,519	(166,036)
Dahomey NWR	798,275	0	798,275	(908,626)
D'Arbonne NWR	1,533,495	0	1,533,495	(345,427)
Delta NWR	13,311,270	0	13,311,270	726,131
Eufaula NWR	1,292,572	0	1,292,572	(700,230)
Felsenthal NWR	1,970,820	0	1,970,820	(1,621,051)
Grand Bay NWR	296,225	0	296,225	(746,839)
Grand Cote NWR	1,595,982	7,704,938	9,300,920	(2,466,532)
Green River NWR	0	0	0	(5,216,746)
Handy Brake NWR	12,564	0	12,564	(719,865)
Hatchie NWR	886,352	4,663,474	5,549,825	1,208,325
Hillside NWR	1,132,744	0	1,132,744	210,039
Holla Bend NWR	383,685	4,808,553	5,192,237	(15,674)
Holt Collier NWR	289,109	0	289,109	120,725
Lacassine NWR	7,432,145	1,089,140	8,521,285	(5,370,777)

Appendix C. Table B Continued.

National Wildlife Refuge	Natural Energy	Crop Energy	Total Energy	Δ Energy
Lake Isom NWR	1,022,463	2,828,450	3,850,913	(3,274,650)
Lake Ophelia NWR	1,264,233	8,621,250	9,885,483	4,817,011
Lake Woodruff NWR	3,017,011	14,438	3,031,448	2,450,070
Lower Hatchie NWR	736,468	4,266,113	5,002,581	(5,915,600)
Loxahatchee NWR	6,964,740	0	6,964,740	4,818,818
Mackay Island NWR	2,437,250	61,750	2,499,000	320,371
Mandalay NWR	1,452,301	0	1,452,301	(1,781,798)
Mathews Brake NWR	177,840	0	177,840	(31,135)
Mattamuskeet NWR	4,871,080	0	4,871,080	(7,706,211)
Merritt Island NWR	5,929,945	0	5,929,945	294,528
Morgan Brake NWR	2,741,531	3,230,000	5,971,531	(844,891)
Noxubee NWR	1,182,541	1,140,000	2,322,541	(1,120,859)
Overflow NWR	2,249,508	1,425,000	3,674,508	(261,905)
Panther Swamp NWR	1,924,302	11,886,250	13,810,552	2,833,783
Pea Island NWR	1,278,500	0	1,278,500	(1,264,719)
Pee Dee NWR	314,472	4,011,500	4,325,972	1,784,836
Pocosin Lakes NWR	1,306,653	8,167,500	9,474,153	2,190,775
Pond Creek NWR	604,171	0	604,171	(1,822,094)
Red River NWR	2,204,622	608,750	2,813,372	(5,538,658)
Reelfoot NWR	980,443	5,653,150	6,633,593	(10,449,336)
Roanoke River NWR	512,519	0	512,519	(2,077,841)
Sabine NWR	20,990,795	0	20,990,795	13,022,691
Santee NWR	1,570,578	475,000	2,045,578	(3,431,930)
Savannah NWR	2,718,735	0	2,718,735	733,945
St. Catherine Creek NWR	1,648,750	950,000	2,598,750	355,779
St. Marks NWR	2,354,061	0	2,354,061	1,341,162
Swanquarter NWR	690,847	0	690,847	(1,746,088)
Tallahatchie NWR	437,860	475,000	912,860	(8,175,403)
Tennessee NWR - Overall	4,532,225	13,733,338	18,265,563	(3,152,677)
Big Sandy	600,850	1,665,788	2,266,638	(4,456,440)
Busseltown Unit	387,750	2,834,075	3,221,825	1,685,090
Duck River Unit	3,543,625	9,233,475	12,777,100	(381,327)
Tensas River NWR	1,560,441	2,565,000	4,125,441	306,737
Theodore Roosevelt NWR	6,241	0	6,241	(215,663)
Upper Ouachita NWR	1,992,763	6,397,500	8,390,263	385,975
Waccamaw NWR	1,121,302	755,250	1,876,552	(1,633,079)
Wapanocca NWR	511,150	549,825	1,060,975	(7,393,349)
Wheeler NWR	1,868,208	14,180,125	16,048,333	851,746
White River NWR	5,275,709	4,132,500	9,408,209	(28,194,299)
Yazoo NWR	1,052,533	5,088,438	6,140,971	736,999
Total	**193,915,937**	**170,116,341**	**364,032,279**	**(140,589,882)**

Appendix D. Template for waterfowl objective expression in a SMART format that may be used by a National Wildlife Refuge in a planning document. Text in purple font will be modified for each NWR and management objectives may be added or subtracted based on resources of concern (in **bold** font) for each NWR. "Upper River" NWR used as a hypothetical example.

National Wildlife Refuge: Upper River NWR

Resource of Concern: Waterfowl (dabbling ducks and diving ducks)

Focal Species: mallard, ring-necked duck, wood duck

Overall Objective

Provide a diversity of habitat resources for migratory and wintering waterfowl at Upper River NWR totaling 4.3 million waterfowl energy days (WED), including 3.9 million WED for 54,550 dabbling ducks, 0.1 million WEDs for 2,540 diving ducks, and 0.3 million WED for 1,330 geese during autumn and spring migration and winter periods.

Management Objectives

1. Maintain and manage 165 acres of **unharvested corn** that provide at least 35,000 WED/ac in units Hillville, Windrow, and Freeman that are flooded for at least 90 days during 1 November – 1 April annually to meet a portion of the foraging habitat needs of dabbling ducks (e.g., mallard, northern pintail, American green-winged teal) and diving ducks (e.g., ring-necked duck) at Upper River NWR.

2. Maintain and manage 200 acres of **freshwater emergent wetlands managed for moist-soil vegetation** with ≥80% desirable plant species (e.g., *barnyardgrass, Pennsylvania smartweed, fall panicgrass*) and ≤20% undesirable or invasive species (e.g., *cocklebur, coffeeweed*) that provide at least 1,800 WED/ac in units Hillville, Windrow, and Coffee-Morris that are flooded for at least 90 days during 1 November – 1 April annually to meet a portion of the foraging habitat needs of dabbling ducks (e.g., mallard, northern pintail, American green-winged teal) and diving ducks (e.g., ring-necked duck, lesser scaup) at Upper River NWR.

2. Maintain and manage 175 acres of **freshwater emergent wetlands under a semi-permanent water regime** with ≥80% desirable plant species (e.g., *cattail, giant cutgrass*) and ≤20% undesirable or invasive plant species (e.g., *black willow*) that provide at least 500 WED/ac in units Windrow, Yellowlegs, and Pintail that are flooded for at least 90 days during 1 November – 1 March and again 1 April – 30 June annually to meet a portion of the foraging habitat needs of dabbling ducks (e.g., gadwall, American wigeon) and diving ducks (e.g., ring-necked duck) while also providing brood rearing habitat resources for wood ducks and nesting resources for secretive marsh birds at Upper River NWR.

4. Maintain and manage 500 acres of **submersed aquatic vegetation** that consists of ≥80% high quality plant species (e.g., *coontail, elodea*) and ≤20% undesirable or invasive species (e.g., *American lotus*) providing at least 500 WED/ac that are available in units O'Neil Lake and Goose Lake for at least 90 days during 1 November – 1 April annually to meet a portion of the foraging habitat needs of dabbling ducks (e.g., gadwall, American wigeon) and diving ducks (e.g., canvasback, redhead) at Upper River NWR.

5. Maintain and manage 9,260 acres of **forested wetlands** to provide at least 100 WED/ac in floodplain areas of the Upper River annually to meet a portion of the foraging habitat needs of dabbling ducks (e.g., mallard, wood duck) at Upper River NWR.