# APPENDIX F-7: WATERFOWL

## ABSTRACT

Construction and implementation of the pump station for the 2020 Supplement No. 2 to the 2007 Final Supplement No. 1 to the 1982 Yazoo Area Pump Project Final Environmental Impact Statement (FEIS), hereinafter referred to as the 2007 FSEIS of the Yazoo Basin, Yazoo Backwater, Mississippi, Project will result in changes to available wintering waterfowl habitat within the Mississippi Alluvial Valley (MAV). To determine the impacts of the Proposed Plan, an index for determining the number of days a single individual duck could be supported based on the food resources available in that area is calculated. This index is referred to as a duck-use-day (DUD) and it requires knowledge of the current land use and winter food availability within an area, hydrologic data, energy of food items, deterioration rates of food items, and the energy requirements of waterfowl.

The Proposed Plan incorporates both a No Action and Action Alternative according to the implementation of a 14,000 cubic feet per second pump station that is operational once water levels reach 87 feet NGVD. The No Action and Action Alternatives will result in an average of 10,858,339 and 9,509,111 DUDs, respectively, during the winter waterfowl period. A reduction in flooded area will result from operation of the pump station which will result in a decrease in annual DUDs by 1,349,228, on average. Forested habitats will be the most impacted by changes in hydrology between the alternatives; however, all habitat types will experience some level of reduced flooding at desirable waterfowl feeding depths (i.e. ≤ 18 inches).

The potential for creating moist-soil management units using structural means or green-tree reservoirs along with enhancing bottomland hardwood forests (BLH) will more than offset the loss of foraging habitat to wintering waterfowl in the Yazoo Basin with proper mitigation to compensate for the loss of DUD under the Proposed Plan. Long-term impacts to wintering waterfowl are likely to be improved by incorporating mitigation recommendations from this report in addition to following guidelines from the Lower Mississippi Valley Joint Venture. Improved forest management will not only benefit waterfowl during the winter period, but also greatly improve habitat conditions year-round for the majority of wildlife species that inhabit BLH.

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## INTRODUCTION

Construction and implementation of the 14,000 cubic feet per second (cfs) pump station, as part of the Proposed Plan, within the Yazoo Study Area will result in changes to available wintering waterfowl habitat within the Mississippi Alluvial Valley (MAV). To determine the impacts of the pump operation, a standard practice is to conduct a landscape analysis that provides an index of how many waterfowl an area can support according to food resources that are present within a particular habitat. This index refers to the number of duck-use-days (DUDs) or simply the number of days a single individual duck could be supported based on the food resources available in that area. The most basic representation for a DUD is the formula:

$$Species_{1...m}DUD = \frac{\sum(F_{1...j})(T_{1...l})}{D_{1...m}}$$

Where,

$F$ = the potential food yield (g/ha) for food types $_{i...j}$ in the habitat type $_{1...k}$

$T$ = TME[1] (kcal/g) of specific food types $_{1...l}$

$D$ = DEE[2] of Species $_{1...m}$ in kcal/day and is 4x RMR

RMR[3] = $100.7W^{0.74}$

And, W = weighted body mass of species $_{1...m}$ in kg

True metabolizable energy (TME) is the amount of energy available to waterfowl from their diet

[2] Daily existence energy (DEE) is the number of kilocalories (kcal) an individual duck needs for one day

[3] Resting Metabolic Rate (RMR) accounts for conditions under which data are obtained from test animals, rather than implying a true basal rate of energy use

DUD calculations for the Yazoo Basin, Yazoo Backwater, Mississippi, Project are based on data and formulas within "A manual for calculating duck-use-days to determine habitat resource values and waterfowl population energetic requirements in the Mississippi Alluvial Valley," hereafter referred to as DUD manual (Heitmeyer 2010). This method has been used on U.S. Army Corps of Engineers (USACE) flood control projects to quantify the impact of altering hydrology on traditional waterfowl wintering areas and for designing appropriate mitigation measures (Heitmeyer et al. 2011; USACE 2013, 2020). The model for calculating DUD has been certified by USACE.

By converting to DUDs, units are comparable across habitat types which facilitates both mitigation efforts and management decisions. This is particularly useful when the loss of one habitat must be mitigated with another habitat type due to practical constraints or the need to meet multiple ecosystem management goals. DUDs provide an objective index of the relative value of different habitats for dabbling ducks as winter foraging habitats.

## Historical Perspective

Historically, the MAV was composed of mostly bottomland hardwood forests (BLH), swamps, and bayous, including the largest forested wetland in North America (25 million acres) extending approximately from southeastern Missouri to southern Louisiana. Conversion of forest to agricultural land has resulted in over 80 percent of the forest in this region cleared. Historically, most of the MAV was subject to periodic flooding by the Mississippi River and its tributaries; however, following the Flood Control Act of 1941, hydrologic relationships in the MAV were altered by federally funded water resource developments for flood control (Reinecke et al. 1988, King et al. 2006, Remo et al. 2018). The construction of 1,500 miles of mainline levees along both banks of the Mississippi River under the Mississippi River and Tributaries (MR&T) Project, enabled thousands of acres of BLH to be cleared for agricultural production. The most productive agriculture lands within the Yazoo Basin were those that generally were higher in elevation with well-drained soils.

Following the completion of interior flood control projects within the MAV, the period from 1950 through the 1970's saw the expansion of agriculture into the lower, wetter, flood prone land. During this time period, approximately 3.5 million acres of wooded wetlands were converted to agriculture production (MacDonald et al. 1979, Oswalt 2013). The futility of farming marginal, floodprone land was made evident during the devastating floods that occurred from 1973 through 1993, despite the occasional periods of drought. As the result of this extended period of flooding, Congress enacted legislation to protect and restore wetlands (marginal, flood prone agricultural land brought into production during the period from 1950-1970): the 1985 Farm Bill, the Emergency Wetlands Protection Act of 1986, the Water Resources Development Act of 1986, the Agriculture Credit Act of 1987, the Conservation Reserve Program, the 1990 Farm Bill, the Food Security Act of 1992, the Wetlands Reserve Program (WRP), and the Federal Agriculture Improvement and Reform Act of 1996. For example, under the provisions of WRP, the federal government pays land owners fair market value for marginal cropland (farmed wetlands) and assists in replanting these areas in bottomland hardwood species. Today, the trend of Federal policy is decidedly favorable toward (1) wetland restoration that will benefit waterfowl and other wildlife dependent on wetland habitat, and (2) sound floodplain management. Both WRP and the U.S. Fish and Wildlife (USFWS) Partners for Fish and Wildlife Program have demonstrated that these federal wetland restoration programs have successfully met project goals by providing habitat to species of greatest conservation need and to other wetland associated wildlife (Benson et al. 2018).

The BLH that remain along the Mississippi River are among the nation's most important wetlands. These forested wetlands fulfill special waterfowl habitat requirements not provided by open lands. Wooded habitats produce nutritious foods for waterfowl and provide secure roosting areas, cover during inclement weather, loafing sites, protection from predators, and isolation for pair formation. Despite changes to the landscape and hydrology in the MAV, it remains a critical ecoregion for North American waterfowl and other wildlife (Kaminski 1999, Elliott et al 2020). Approximately 40 percent of the Mississippi Flyway's waterfowl and 60 percent of all U.S. bird species either migrate through or winter in the MAV (LMVJV 2015). The MAV is considered the most important wintering location for Mallard (*Anas platyrhynchos*) and Wood Duck (*Aix sponsa*) populations as well as wintering significant numbers of Green-winged Teal

(*Anas crecca*), Northern Shoveler (*Spatula clypeata*), and Gadwall (*Mareca strepera*) (LMVJV 2015).

## Habitat Requirements

The loss and degradation of habitat has been identified as the major waterfowl management problem in North America (USFWS and Canadian Wildlife Service 1986). Habitat requirements for wintering waterfowl include three components: availability, utilization, and suitability in meeting social behavioral requirements. Size of the migratory waterfowl population in the MAV is a direct function of these three components. Managed and unmanaged wintering waterfowl habitats are present in the MAV. Managed habitats, using structural measures and vegetation manipulation, are primarily found on federal and state lands, and represent the core wintering habitat during dry (below normal rainfall) years. Temporary and seasonal wetlands tend to be large producers of waterfowl food supplies. Unmanaged winter habitat provides important foraging habitat to wintering waterfowl during years of normal or above normal rainfall. The increased availability of wintering habitat also affects the distribution of wintering waterfowl in the MAV (Hagy et al. 2014). Proportionately more waterfowl have been found to winter in the MAV during periods of above normal rainfall and cold winters (Nichols et al. 1983, Reinecke et al. 1987). However, unmanaged and flood susceptible habitats within the MAV, which are important to wintering waterfowl, have long been subject to federal flood control drainage projects that have altered the historic flood events.

Relationships exist between the availability of wetland habitat and food during winter, and waterfowl physiological, behavioral, and population responses (Kaminski 1999). Hydrology and resulting wetland habitat as well as intrinsic resources are critical proximate factors related to waterfowl use of alluvial environments like the MAV (Fredrickson and Heitmeyer 1988). Increased wetland availability during the winter likely improves foraging opportunities and food availability for Mallards and other waterfowl (Wright 1961, Delnicki and Reinecke 1986, Reinecke et al 1988, Wehrle et al 1995). These improved opportunities and availability are related to increased body weights in Mallards (Delnicke and Reinecke 1986), earlier prebasic molt and acquisition of basic (breeding) plumage in female Mallards (Heitmeyer 1987, Richardson and Kaminski 1992), and increased Mallard survival (Reinecke et al. 1987) and reproductive rates (Heitmeyer and Fredrickson 1981, Kaminski and Gluesing 1987).

## Population Status

Within North America, several species of waterfowl, including Mallards, are showing signs of recovery approaching or exceeding the population levels recorded in the 1950's according to the USFWS Waterfowl Breeding Population and Habitat Survey which is conducted on an annual basis (USFWS 2019). Total duck abundance was 38.9 million birds, an increase of 10 percent higher than the 1955-2018 average (USFWS 2019). A comparison of average total duck numbers of 37.4 million for 1955-1960 to that of 45 million ducks during 2015-2019 resulted in an approximate 20% increase (USFWS 2019). Long-term trends generally display an increase in populations for Mallards, Gadwalls, Green-winged Teal, Blue-winged Teal (*Spatula discors*), Northern Shoveler, and Redheads (*Aythya americana*). Northern Pintails (*Anas acuta*) and Scaup (*Aythya* spp.) have yet to recover from long-term averages, while Canvasback (*Aythya* *valisineria*) and American Wigeon (*Mareca americana*) populations appear to have remained relatively stable over time (Figure 1).

While the annual breeding duck surveys are the most reliable estimates of waterfowl populations, population estimates are also available from extensive surveys of wintering ducks as well as waterfowl harvest data. The midwinter waterfowl survey for the Mississippi Flyway, conducted by the USFWS and the states, is an attempt to count the total number of ducks of each species (Fronczak 2019). Total duck abundance in 2019 was 5.75 million birds, a decrease of 14 percent over the long-term average (1955-2018). However, the midwinter average population estimate for the past decade (2011-2020) was approximately 7.5 million ducks, an increase of nearly 12 percent over the long-term average (Table 1; Fronczak 2019). Caution must be taken when considering midwinter counts as these population estimates are not considered reliable for measuring trends in abundance of most duck species because of the large area which must be surveyed, and the difficulty of counting birds, especially in wooded habitats, and the lack of a valid statistical sampling scheme. However, these surveys do provide useful, general information on wintering waterfowl population levels.

The Lower Mississippi Valley Joint Venture (LMVJV) has taken the lead on establishing population and habitat objectives for most birds in the MAV. For wintering waterfowl, these objectives include targets for American Black Duck (*Anas rubripes*) (53,000), American Wigeon (288,000), Canvasback (43,000), Gadwall (430,000), Scaup (1,354,000), Green-winged Teal (476,000), Mallard (3,239,000), Northern Pintail (329,000), Northern Shoveler (89,000), Redhead (60,000), Ring-necked Duck (*Aythya collaris*) (277,000), Ruddy Duck (*Oxyura jamaicensis*) (55,000) and Wood Duck (1,622,000). Estimates for dabbling ducks in the Mississippi Flyway during 2018 were among the highest on record with approximately 6.8 million ducks (Fronczak 2019). Recovery of waterfowl populations can be attributed to many conservation efforts including extensive funding to restore both breeding and wintering habitat. Expansion of the USFWS National Wildlife Refuge system, creation of the duck stamp to fund wetland restoration, and large-scale participation with non-governmental organizations such as Ducks Unlimited and Delta Waterfowl have and will continue to play a key role in sustaining waterfowl populations. Legislation such as the Migratory Bird Treaty Act and North American Wetlands Conservation Act have provided critical protection for waterfowl (Anderson et al. 2018). However, habitat loss as well as factors such as climate change continue to be significant threats to wildlife populations including waterfowl (Mantyka-Pringle et al. 2012). Therefore, it remains critical to protect the resources on which waterfowl are dependent.

## METHODS

The information requirements to estimate DUDs are: (1) current land use, including crop type; (2) extent, duration, and depth of flooding; (3) amount of winter food present by land use; (4) energy of food items; (5) deterioration rates of food items; and (6) energy requirements of waterfowl. To facilitate calculation, food item densities, deterioration/resource availability rates (by month), and energy values were aggregated within a given habitat type. The aggregated values for each habitat condition were formulated within a spreadsheet so that a final estimate of DUDs could be generated based on acreage.

The U.S. Army Engineer Research and Development Center, Environmental Laboratory (ERDC-EL) calculated hectares of 10 habitat categories used by wintering waterfowl within the Yazoo Study Area that flooded less than 18 inches during the period of 1 November to 28 February according to the ENVIRO-DUCK hydrological model developed by the U.S. Army Corps of Engineers, Vicksburg District (MVK). The Enviro-Duck Program calculates area by acres; however, DUDs are calculated according to hectares within the DUD manual. Therefore, ERDC-EL converted between the two units as necessary. For example, acres from the Enviro-Duck Program were converted to hectares prior to energetic calculations within the DUD manual. For ease of use within this Appendix, ERDC-EL also reports acres as it relates to mitigation requirements. Habitat categories were: 1) Corn, 2) Rice, 3) Soybeans, 4) Sorghum/Milo, 5) BLH naturally forested areas with average density of small, medium, and large trees containing 5 percent canopy gaps, 6) BLH naturally forested areas with average density of small, medium, and large trees containing 10% canopy gaps, 7) BLH naturally forested areas with average density of small, medium, and large trees containing 20+ percent canopy gaps , 8) Grassland/Seasonal Herbaceous Wetland (SHM passively unmanaged), 9) Open Water/Aquatic (OW-AQ), and 10) Shrub/Scrub. Other land cover types in the Yazoo Study Area included developed lands (e.g., roads, residences, building sites, cities) and other agricultural lands that primarily include winter wheat or cotton. ERDC-EL did not analyze these latter land cover categories for DUD because they do not provide significant available waterfowl food sources (e.g., cotton, developed lands) or they do not require flooding for waterfowl use.

ERDC-EL determined food and energy values for the 10 habitat categories, by specified time period (month) from the DUD manual (Heitmeyer 2010; Table 2). These energy values were related to a daily existence energy (DEE) for a Mallard (1 Mallard DEE = 452.44 kcal/day) and divided by the number of hectares of each flooded habitat to determine the potential DUDs/hectare/specified time period. The amount of food available on a unit area was determined from tables within the DUD manual (Heitmeyer 2010). For this waterfowl section, the methodology was further refined to include information on seed deterioration rates, seed availability/abundance, and invertebrate availability/abundance that was incorporated into energetic formulas (Heitmeyer 2010; Table 3). Although there are multiple species of waterfowl present in the project area, the Mallard was selected to standardize all of the habitats found in the Yazoo Study Area. Mallards are the most abundant duck species in the Mississippi Flyway during migration periods, they utilize a variety of flooded forests and inundated agricultural fields, and a large amount of scientific research has been conducted on their habitat requirements and foraging ecology.

Waterfowl foraging habitat, regardless of food value, is only of use if available. Food availability is dependent on extent, duration, and depth of flooding. Ducks use relatively shallow water areas, 18 inches or less, for feeding. Using extensive hydrological data for the period-of-record (POR; 1978-2018), MVK estimated seasonal acres flooded 18 inches or less for the wintering season using the ENVIRO-DUCK model. This analysis within the model uses two types of wintering waterfowl habitat: resting and feeding. Resting habitat consists of large bodies of water with more than two feet of depth. Feeding habitat is represented by lands flooded less than or equal to 18 inches in depth, from November through February. During the winter waterfowl season the river stages are typically on a gradual rise, which provides new inundated habitat and feeding areas as the period progresses. The daily acres of feeding habitat were calculated using stage-area curves. The resting habitat is simply all areas inundated each day. The feeding habitat is calculated by finding the difference between the resting area and the aerial extent of a water surface inundated 18 inches or less.

The ENVIRO-DUCK program calculates the resting and feeding acres for each day, sums them for each year, and calculates the annual mean daily acres. The program provides two output files. The first has the daily data, with the stage, resting and feeding area for each day of the waterfowl season. The second output file provides an annual summary of the daily output. The annual summary also provides an overall mean for the study period.

The stage area curves were developed in ArcMap, using flood extents determined by a flood mapping tool (Flood Event Simulation Model, FESM). A series of flood events for elevations 75 through 108 feet, NGVD were modeled in FESM. The FESM mapping tool produces a geo-TIFF file, which is then incorporated into ArcMap. ArcMap (Spatial Analyst-zonal tabulation) was then used to determine the aerial extent of flooding for each of those events. The tabulation was imported into Microsoft Excel, and the stage-area curves were constructed in Excel. ArcMap was also used to determine the area associated with each river/stream gage location. The 12 digit Hydrologic Units (HUC-12) from the Yazoo Basin were used for these calculations (Figure 2).

The Statistical Analysis System (SAS) Procedure Univariate was used to calculate the duration. SAS calculated the 1, 5, 10, 25, 50, 75, 90, 95 and 99th percentile of the POR stage data. The data was sorted by season and the 75th percentile of the winter season was used for determining areas that typically are suitable for foraging by waterfowl in the Yazoo Study Area during the POR (Figure 3).

In order to meet the above requirements for calculating DUDs, ERDC-EL determined habitat type and associated food resources within those habitats by acquiring spatial layers of land cover within the Yazoo Study Area. ERDC-EL acquired the spatial extent of the Yazoo Study Area within a geodatabase in ArcGIS from MVK. ERDC-EL used this spatial boundary to determine land classification and features for subsequent analyses. ERDC-EL acquired the USDA National Agriculture Statistics Service (NASS) Cropscape that determines annual crop production (USDA NASS Cropland Data Layer). The Cropscape land cover provides classifications for crop production (e.g., corn, soybean, rice, cotton) as well as other general habitat types (e.g., deciduous forest, shrubland, woody or herbaceous wetlands). The primary categories within the Yazoo Study Area for production years 2015-2019 included cotton, corn, soybean, sorghum/milo, rice, and agricultural browse.

ERDC-EL further refined the forest classification according to canopy cover that was determined using the 2016 U.S. Forest Service Tree Canopy spatial layer (Multi-resolution Land Characteristics Consortium 2018). ERDC-EL created three categories (5 percent, 10 percent, 20+ percent) according to percentage of canopy gaps within the forest cover layer. The forest canopy gap layer was used to inform the model based on Table 10 from the DUD manual which standardizes average herbaceous seed production from percentage of canopy gaps within forests (Heitmeyer 2010). ERDC-EL grouped all cover types referenced as "fallow/idle cropland, grass/pasture, or herbaceous wetlands" into one broader classification of SHM-Passively Unmanaged for incorporation into the DUD manual. One classification with reference to "shrubland" was categorized as Shrub-scrub. Open water/aquatic areas were direct inputs into Table 10 of the DUD manual (Heitmeyer 2010). ERDC-EL classified the remaining land cover groups which contained "developed" land, "barren", or crops that would not contribute as energy for waterfowl as "Other Crop"; these groups were not considered within the DUD model.

Heitmeyer (2010) designated six forest types according to forest composition/major food types which include: BLH-Naturally Flooded (BLH-NF), BLH-Greentree Reservoirs (BLH-GTR), Cypress (*Taxodium distichum*)-Tupelo (*Nyssa sylvatica*), Floodplain Forests, Riverfront Forest, and Dead Timber. ERDC-EL conducted Habitat Evaluation Procedures (HEP) sampling during July 2020 at 53 plots across the Yazoo Study Area. The HEP sampling plots revealed numerous forest types that ranged from young forest stands replanted predominantly in oak species to more mature forests containing a wider diversity of BLH tree species. Heitmeyer (2010) described floodplain forest as the transition zone between riverfront forest and BLH that generally occurs within the 1-2 year flood frequency zone. Floodplain forest are dominated by Elm (*Ulmus* spp.), Ash (*Fraxinus* spp.), Sweetgum (*Liquidambar styraciflua*), Sugarberry/Hackberry (*Celtis* spp.), and Box Elder (*Acer negundo*). Tree species within our HEP sample plots are consistent with the dominant species in floodplain forest; however, oaks did comprise approximately 24 percent of the forest community 10 centimeters diameter at breast height (dbh) or greater. Riverfront forest is characterized by more early successional species such as Willow (*Salix* spp.) and Silver Maple (*Acer saccharinum*) and are associated more within the 1-year flood frequency. Plots that also were consistent with that of riverfront forest were sampled, but these habitats were less frequent. Therefore, all forested areas were conservatively categorized as naturally forested BLH with average density of small, medium, and large trees with 5, 10, or 20+ percent canopy gaps for this analysis. This represents a conservative choice as this category over-represents oak production compared to the actual composition of oaks within our sampled forest plots within the Yazoo Study Area. ERDC-EL was unable to determine if dead timber stands occurred within the project areas based on the spatial layers that were obtained and none were observed within the HEP sample plots. The USDA Cropscape layer was used to define areas containing agricultural resources for waterfowl (i.e., corn, milo/sorghum, rice, or soybean; Figure 4).

The flooded acres of each habitat category were compiled across the five most recent years (2015-2019) according to Heitmeyer (2010) and incorporated them into the 75$^{th}$ percentile hydrologic zone within each of the HUCs to determine the percentage of each habitat category available throughout the winter waterfowl period. The percentages of each habitat category within the 75$^{th}$ percentile hydrologic zone were then used to determine the acres of suitable habitat flooded $\leq$ 18 inches according to the acres generated each month within the Enviro-Duck program. These acreages along with energetic values from Heitmeyer (2010) were incorporated into the spreadsheet (see Supplemental Material in administrative record at MVK) to calculate DUDs for hydrologic conditions comparing the No Action and Action Alternatives. The five-year period was incorporated into the model to account for yearly variability in agricultural crop production, or in some cases areas that remained fallow (e.g., 2019 agricultural production season; Figure 4). In order to factor resource availability during the wintering waterfowl period (1 November- 28 February), each month separately was totaled and then summed the months together to determine the total DUD value; this procedure was also used to calculate DUD for mitigation lands to be reforested as BLH forest or SHM-passively managed moist-soil management (MSM) units.

Mitigation values for DUDs were generated by incorporating mitigation recommendations from the USFWS for different successional habitat types over the 50-year bottomland hardwood restoration period into the current DUD model's habitat categories (Heitmeyer 2010). ERDC-EL calculated each habitat's contribution to DUDs according to 1 hectare (2.47 acres), and then calculated the contribution of that hectare across a 50-year period. Mitigation was based on restoring existing cropland within the 2018 NASS land cover to BLH forest consisting of at least 50 percent red oaks or developing MSM units (i.e. SHM-passively unmanaged). For the BLH restoration, the first five years after planting were given values according to SHM-passively unmanaged as this period will primarily consist of herbaceous growth. The following 15 years (Year 6-20) were not assigned any value towards DUDs as this period will consist of dense woody vegetation that will likely be unsuitable as foraging habitat to wintering waterfowl. Once trees reach the age of 20, oaks begin producing hard mast which contributes to energy resources and were given the category of "BLH-NF, 5% tree gaps and canopy openings, average density, small trees" for 15 years (Year 21-35). The last 15 years (Year 36-50) were assigned "BLH-NF, 5% tree gaps and canopy openings, average density, medium trees". These DUD values for BLH forest were totaled for the 50-year period to determine the amount of mitigation needed to replace flooded habitats used by wintering waterfowl (Table 4). Moist-soil impoundments focus on encouraging growth of seed-producing native wetland plants by mimicking the seasonal wet and dry cycles of natural wetlands (Strader and Stinson 2005). These habitats typically are wet in spring, dry in summer, and wet again in fall and winter. The energetic contribution of MSM units is expected to remain constant each year; therefore, the average annual energetic contribution for MSM units is the same over the 50-year project life.

## RESULTS

The Proposed Plan incorporates a No Action and Action Alternative according to the implementation of a 14,000 cfs pump station that is operational once water levels reach 87 feet NGVD. The No Action and Action Alternatives will result in an average of 10,858,339 (Table 5) and 9,509,111 DUDs (Table 6), respectively, during the winter waterfowl period. A reduction in flooded area will result from construction and operation of the pump station which will result in a decrease in annual DUDs by 1,349,228, on average. (Table 7). Forested habitats will be the most impacted by changes in hydrology between the two alternatives; however, all habitat types will experience some level of reduced flooding at desirable waterfowl feeding depths (i.e., $\leq$ 18 inches).

Construction and operation of the 14,000 cfs pump station in the Yazoo Study Area is expected to alter hydrology and flooded acreage suitable for wintering waterfowl foraging (flooded 18 inches in depth or less) by a reduction of between 85-1,030 acres (Tables 8-9) depending on the month during the winter season.

Ten habitat categories that vary in energetic value based on type of food source contribute to a loss of 67,461,400 DUD from the loss of foraging habitats during November through February over a 50-year project life (Table 7). Therefore, conversion of habitats from lower to higher quality foraging habitats will be required to offset these losses. For instance, croplands currently planted with soybeans and that are flooded at proper depths during the winter season currently provide food resources to waterfowl. If these areas are to be converted to BLH forest than the loss of energetics from soybeans must be taken into account for determining final mitigation values. Mitigation lands that are reforested with a minimum of 50 percent desirable red oak plantings for waterfowl will contribute 224,813 DUD/hectare over a 50-year project life (Table 4). Lands that are converted to MSM units for waterfowl will contribute 338,158.5 DUD/hectare over a 50-year project life. Management strategies that implement MSM units or GTRs through structural components that previously did not flood to proper waterfowl foraging depths will result in 100 percent gains in energetic values to waterfowl. MSM units and GTRs use structural components typically consisting of small levees with a water control structure (e.g., stop-log or gate) to control water levels, in areas that historically did not flood or flooded for only a short duration.

In order to mitigate for the reduction in DUDs between the No Action and Action Alternatives, 300 hectares (741.5 acres) of BLH over a 50-year project life would be required with this approach. However, if currently flooded croplands are to be converted to BLH as mitigation, the loss of DUDs for that acreage must be considered as a loss. Therefore, to fully mitigate for the conversion of a lower quality habitat (i.e. croplands assumed to be in soybean production) to a higher quality BLH forest, additional mitigation credits must be calculated. For example, the conversion of 300 hectares (741.5 acres) of soybeans that currently provide energetic value to wintering waterfowl (893.40 DUD/hectare/year) would require an additional 74.5 hectares (184 acres) of BLH to fully mitigate over a 50-year project life. This results in a total of 374.5 hectares (925.5 acres) of mitigation to convert soybean fields currently flooded during winter months to BLH forest over a 50-year project life. A different scenario where MSM units (SHM-passively unmanaged) are implemented on the landscape would require less mitigation because of the higher energetic value of seeds produced from herbaceous plants every year within this habitat type. Under a scenario where MSM units are created as mitigation, 199.5 hectares (493 acres) of SHM are required to achieve the loss of DUDs associated with the reduction of hydrology once the pump station is operational. The conversion of 199.5 hectares (493 acres) of soybeans that currently provide energetic value to wintering waterfowl would require an additional 30.5 hectares (75.5 acres) of SHM to fully mitigate for additional losses of flooded soybean fields. This results in a total of 230 hectares or 568.5 acres of mitigation to convert soybean fields currently flooded during winter months to SHM-passively unmanaged MSM units for the 50-year project life.

## DISCUSSION

The construction and implementation of the Proposed Plan, which includes a 14,000 cfs pump station to reduce flooding within the Yazoo Study Area will result in a loss of waterfowl habitat acreage. Flooding within the Yazoo Basin is expected to be low in years where the Mississippi River remains below the critical level required to close the Steele Bayou water control structure which allows the Yazoo Basin to drain into the Mississippi River near Vicksburg, Mississippi. However, in years with high precipitation throughout the Mississippi River watershed, the gates of the water control structure will be closed resulting in “backwater” accumulating in the Yazoo

Basin. Depending on local precipitation in the basin, significant flooding may occur even with the implementation of the pump station. Therefore, estimates given in this report are considered to be conservative (i.e., over-estimated loss of DUDs) and do not take into account additional acres that may be receiving significant additional hydrologic inputs in some years.

Conservative approaches were used for classifying forests as suitable foraging habitat for waterfowl within the Yazoo Study Area. All forest types within the Yazoo Study Area were classified according to the DUD manual (Heitmeyer 2010) as "BLH naturally forested areas with an average density of small, medium, and large trees (combined)." Other areas, such as along river corridors, are more characteristic of either riverfront or cypress forest, both of which only contribute a fraction of the energetic value as that of oak-dominated BLH. Forest stand age for many tracts within the Yazoo Study Area were unable to be verified; therefore, the most conservative approach was taken by calculating all forests to be of a higher energetic contribution for foraging waterfowl than what likely occurs throughout the Yazoo Basin. Many areas have been reforested in BLH on public lands (e.g., Theodore Roosevelt National Wildlife Refuge), but are still many years from producing hard-mast that could be utilized by wintering waterfowl. The 2019 USDA NASS Cropscape layer determined additional forested acres in 2019 compared to the previous four years. A spatial analysis conducted by Mitchell et al. (2016) found it difficult to separate newly reforested land from agricultural land. They concluded that forest restoration sites may take more than 5 years before they can be spectrally distinguished from agriculture and another 10 years before they can be separated from scrub-shrub habitats when visualizing these areas using moderate resolution imagery. This may help explain differences between the 2019 forest land cover classification and prior classification within the Yazoo Study Area.

Water levels at or below 87 feet NGVD will continue to support wintering waterfowl regardless of the operation of the pump station. Foraging habitat within any watershed that experiences fluctuations in water levels due to precipitation events are dynamic across the landscape. This is also true for the floodplains within the Yazoo Basin in that as water levels rise or fall, some areas will become unsuitable as water depths exceed the necessary 18 inch threshold while others become suitable as foraging habitat. Therefore, implementation of the pump station will reduce the area suitable for foraging waterfowl; however, large areas of foraging habitats will still be available with the Proposed Plan.

Restoration of BLH forests and/or the construction of GTRs or MSM units that are managed each year to provide the proper flooding regimes should more than offset losses to wintering waterfowl within the Yazoo Study Area following actions within the Proposed Plan. Cropland at or below 87 feet NGVD that are to be converted to BLH forest using prescribed methods from Table 4 of this appendix should ensure the proper hydrological parameters (i.e., 18 inches in depth or less) are met. If insufficient cropland is available to meet hydrological requirements for feeding by waterfowl, construction of GTRs can be used to complete mitigation requirements. Planting a variety of red oak species producing smaller-sized acorns and tolerable of periodic flooding, such as Pin Oak (*Quercus palustris*), Water Oak (*Q. nigra*), Willow Oak, (*Q. phellos*), Cherrybark Oak (*Q. falcate*), and Nutall Oak (*Q. texana*) will be most beneficial to wintering waterfowl in the MAV. Actions that are undertaken to mitigate for the loss of DUDs will be coordinated with the local USFWS Ecological Service Field Office to ensure that proper management for wintering waterfowl occurs within the Yazoo Basin.

# TABLES

Table 1. Number of ducks observed during the midwinter waterfowl survey of the Mississippi flyway. Original table from Waterfowl Harvest and Population Survey Data (Fronczak 2019).

| YEAR | MN[2] | WI | MI | IA | IL | IN | OH | MO | KY | AR | TN | LA | MS | AL | MFTOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Continued from previous page | | | | | | | | | | | | | | |
| 2001 | 30,056 | 50,147 | 78,321 | 9,087 | 98,580 | 15,812 | 101,200 | 85,701 | 113,679 | 604,240 | 481,138 | 5,818,758 | 180,932 | 114,882 | 7,782,533 |
| 2002 | 33,262 | 94,388 | 176,482 | 117,790 | 189,147 | 71,795 | 118,656 | 589,454 | 118,139 | 1,143,044 | 467,408 | 3,644,897 | 353,936 | 112,436 | 7,230,834 |
| 2003 | 27,691 | 165,093 | 101,379 | 119,353 | 159,660 | 10,274 | 71,265 | 300,014 | 43,827 | 553,397 | 344,658 | 3,129,665 | 209,799 | 88,522 | 5,324,597 |
| 2004 | 40,984 | NS | 185,287 | 34,095 | 216,950 | 9,904 | 85,324 | 641,185 | 35,163 | 298,149 | 256,290 | 3,852,088 | 188,831 | 86,963 | 5,931,213 |
| 2005 | 31,792 | 101,645 | 85,300 | 25,448 | 286,821 | 6,505 | 53,219 | 691,470 | 85,076 | 567,243 | 397,019 | 3,105,093 | 124,133 | 76,685 | 5,637,449 |
| 2006* | 22,983 | 129,952 | 63,865 | 28,414 | 358,372 | 25,870 | 95,775 | 572,741 | 104,307 | 267,928 | 792,506 | 3,213,419 | 336,635 | 94,721 | 6,107,488 |
| 2007 | 12,426 | 79,658 | 155,827 | 161,241 | 177,152 | 19,448 | 102,179 | 530,455 | 65,648 | 485,502 | 376,254 | 4,737,227 | 144,977 | 68,895 | 7,116,889 |
| 2008 | 15,105 | 119,249 | 94,809 | 24,439 | 150,794 | 9,890 | 61,275 | 394,515 | 138,863 | 668,129 | 874,307 | 2,148,068 | 540,562 | 104,499 | 5,344,504 |
| 2009 | 28,238 | 69,340 | 105,262 | 19,820 | 127,225 | 23,655 | 94,758 | 367,441 | 101,679 | 910,353 | 518,139 | 2,011,575 | 546,561 | 117,771 | 5,041,817 |
| 2010[1] | 25,985 | 77,473 | 157,401 | 21,787 | 148,917 | 14,533 | 48,561 | 147,468 | 107,027 | 3,013,623 | 850,266 | 3,434,357 | 934,140 | 65,152 | 9,046,690 |
| 2011 | 28,768 | 89,410 | 92,755 | 35,946 | 198,357 | 60,184 | 73,995 | 709,861 | 77,359 | 1,227,393 | 743,307 | 3,900,893 | 676,670 | 85,694 | 8,000,592 |
| 2012 | 30,465 | 119,522 | NS | 67,471 | 451,645 | 83,266 | 100,413 | 681,265 | 90,740 | 1,133,622 | 794,602 | 3,514,313 | 663,054 | 81,177 | 7,811,555 |
| 2013 | 14,940 | 80,825 | NS | 77,972 | 446,043 | 23,845 | 119,592 | 621,976 | 116,205 | 562,237 | 695,984 | 3,133,372 | 508,637 | 96,397 | 6,498,025 |
| 2014 | 16,091 | 45,423 | 101,858 | 68,830 | 150,906 | 30,062 | 79,816 | 396,079 | 108,410 | 1,017,246 | 717,302 | 4,054,418 | 1,281,276 | 81,264 | 8,148,981 |
| 2015 | 19,785 | 49,872 | 193,784 | 40,527 | 457,620 | 23,659 | 173,060 | 638,919 | 122,178 | 1,312,653 | 630,529 | 3,825,167 | 679,465 | 84,516 | 8,251,734 |
| 2016 | 24,730 | 127,902 | 209,411 | 61,314 | 796,235 | 36,014 | 114,061 | 753,452 | 52,777 | 1,065,338 | 862,482 | 2,485,532 | 537,911 | 60,684 | 7,187,843 |
| 2017 | 19,028 | 60,243 | 148,477 | 53,620 | 437,325 | 29,169 | 67,778 | 809,885 | 81,416 | 867,124 | 1,108,626 | 2,782,208 | 1,446,429 | 77,717 | 7,989,045 |
| 2018 | 9,856 | 64,125 | 105,241 | 45,498 | 358,629 | 42,248 | 104,427 | 492,877 | 100,258 | 1,241,709 | 787,519 | 3,499,143 | 1,150,947 | 82,063 | 8,084,540 |
| 2019 | | 51,873 | 117,489 | 57,793 | 493,131 | 18,230 | 43,221 | 854,067 | 50,767 | 1,092,133 | 86,347 | 2,502,078 | 371,834 | 21,990 | 5,760,953 |
| AVERAGES: | | | | | | | | | | | | | | | |
| 55-60 | 15,867 | 42,433 | 138,717 | 91,567 | 976,433 | 556,067 | 101,283 | 368,100 | 156,983 | 1,328,217 | 390,117 | 2,271,283 | 159,567 | 89,867 | 6,686,500 |
| 61-70 | 11,670 | 35,020 | 49,410 | 138,830 | 400,670 | 61,510 | 94,560 | 322,950 | 57,510 | 1,289,020 | 404,080 | 4,934,590 | 244,480 | 106,130 | 8,150,430 |
| 71-80 | 25,890 | 20,640 | 42,540 | 114,190 | 411,960 | 37,380 | 64,780 | 312,380 | 42,330 | 931,690 | 395,680 | 3,798,880 | 400,600 | 96,030 | 6,694,970 |
| 81-90 | 26,428 | 35,632 | 47,265 | 56,290 | 222,754 | 26,340 | 62,768 | 195,680 | 32,286 | 1,005,389 | 374,195 | 3,077,005 | 262,650 | 79,514 | 5,504,197 |
| 91-00 | 16,902 | 49,389 | 110,141 | 28,234 | 195,650 | 32,347 | 126,204 | 388,455 | 49,833 | 891,267 | 445,882 | 3,506,333 | 222,893 | 91,048 | 6,143,563 |
| 01-10 | 26,852 | 98,549 | 120,393 | 56,147 | 191,362 | 20,769 | 83,221 | 432,044 | 91,341 | 851,161 | 535,799 | 3,509,515 | 356,051 | 93,053 | 6,456,401 |
| 11-20 | 20,458 | 76,577 | 138,431 | 56,552 | 421,099 | 38,520 | 97,374 | 662,042 | 88,901 | 1,057,717 | 714,078 | 3,299,680 | 812,914 | 74,611 | 7,525,919 |
| Long-term | 20,880 | 50,587 | 86,914 | 76,851 | 367,268 | 84,101 | 89,221 | 379,724 | 68,846 | 1,033,447 | 466,519 | 3,562,893 | 356,005 | 90,284 | 6,728,429 |

* - Incomplete survey. Estimates for the flyway and some states (IL, LA, 93; LA, MS, 97; MS, 06) are not comparable with other years. ** - NS = No survey DF 9/27/2019

[1]-Arkansas 2010: switched to a transect survey in Zone 2 & 3 [2]-MN: 2019 discontinued survey

Table 2. The total number of DUDs within each habitat type by month and the final DUD value resulting from the sum of DUDs from November through February that are incorporated into the DUD formula with land acreage. These values are derived from Heitmeyer (2010), and are incorporated into a spreadsheet (see Supplemental Material in administrative record at MVK) that was certified by USACE for the DUD model.

| Habitat | Nov | Dec | Jan | Feb | Nov-Feb Totals |
|---|---|---|---|---|---|
| BLH-NF, 5% tree gaps and canopy openings, average density, Combined trees | 1,583 | 1,784 | 1,684 | 1,552 | 6,603 |
| BLH-NF, 10% tree gaps and canopy openings, average density, Combined trees | 1,682 | 1,872 | 1,760 | 1,617 | 6,931 |
| BLH-NF, 20+% tree gaps and canopy openings, average density, Combined trees | 1,878 | 2,045 | 1,909 | 1,743 | 7,575 |
| Shrub/Scrub | 738 | 694 | 727 | 722 | 2,881 |
| SHM-Passively Unmanaged | 1,987 | 1,774 | 1,598 | 1,404 | 6,763 |
| OW-AQ | 15 | 31 | 77 | 108 | 232 |
| Agricultural (corn) | 983 | 747 | 517 | 520 | 2,767 |
| Agricultural (soybeans) | 302 | 236 | 177 | 179 | 893 |
| Agricultural (milo) | 529 | 406 | 290 | 293 | 1,518 |
| Agricultural (rice) | 529 | 406 | 290 | 293 | 1,518 |

Table 3. Estimated percent of maximum annual production of major food items available to wintering waterfowl in the MAV during November to February. Table obtained from Heitmeyer (2010; Table 14 of DUD manual).

| Food Type | Nov | Dec | Jan | Feb |
|---|---|---|---|---|
| Herbaceous Seeds | 70 | 60 | 50 | 40 |
| Aquatic Seeds | 70 | 50 | 30 | 20 |
| Mast | 80 | 90 | 80 | 70 |
| Below-ground Tubers | 90 | 90 | 90 | 90 |
| Above-ground Browse | 60 | 50 | 40 | 50 |
| Aquatic Plants | 40 | 20 | 20 | 20 |
| Invertebrates | 10 | 20 | 50 | 70 |
| Agricultural Grains | 40 | 30 | 20 | 20 |
| Agricultural Browse | 30 | 50 | 70 | 80 |

Table 4. Mitigation in terms of number of duck-use-days across the winter period for waterfowl (Mallard) for one hectare of land replanted with average density of oaks in a bottomland hardwood forest over the course of 50 years.

| Habitat Type[a] | Project Life (Years) | Nov-Feb Totals | Years | Total DUDs |
|---|---|---|---|---|
| SHM-Passively Unmanaged | 1-5 | 6,763.17 | 5 | 33,816 |
| Densely populated early-successional forest[b] | 6-20 | 0.00 | 15 | 0 |
| BLH-NF, 5% tree gaps and canopy openings, average density, small trees | 21-35 | 6,130.52 | 15 | 91,958 |
| BLH-NF, 5% tree gaps and canopy openings, average density, medium trees | 36-50 | 6,602.63 | 15 | 99,039 |
| Total number of DUD for mitigation across 50 years for 1 hectare (2.47 acres) | | | 50 | 224,813 |

[a] Habitats descriptions and DUD values from Heitmeyer (2010).

[b] Habitat is deemed unsuitable for wintering waterfowl between years 6-20 as the reforested BLH stand transitions from herbaceous to an early, densely forested successional state.

Table 5. Number of duck-use-days associated with each habitat during the period 2015-2019 for the No Action Alternative averaged across the period-of-record (1978-2018).

| | No Action Alternative-Total DUD (Nov-Feb) | | | | | |
|---|---|---|---|---|---|---|
| Habitat Type | 2015 | 2016 | 2017 | 2018 | 2019 | Average |
| Corn | 2,635 | 6,866 | 6128 | 1,485 | 604 | 3,544 |
| Cotton | 0 | 0 | 0 | 0 | 0 | 0 |
| Forest-5% | 2,706,223 | 2706158 | 2,705,694 | 2,705,256 | 2,707,204 | 2,706,107 |
| Forest-10% | 2,134,285 | 2134658 | 2,125,960 | 2,126,667 | 2,138,642 | 2,132,043 |
| Forest-20+% | 5,771,054 | 5799288 | 5,738,233 | 5,670,390 | 5,554,656 | 5,706,724 |
| Milo | 235 | 14 | 43 | 0 | 0 | 59 |
| Open Water/Aquatic | 43,790 | 42395 | 41,844 | 40,759 | 42,154 | 42,188 |
| Other | 0 | 0 | 0 | 0 | 0 | 0 |
| Rice | 441 | 419 | 62 | 1,000 | 327 | 450 |
| Scrub-shrub | 20,477 | 19640 | 67,211 | 70,347 | 82 | 35,552 |
| SHM-Passively Managed | 44,125 | 97529 | 34,872 | 69,321 | 705,072 | 190,184 |
| Soybeans | 54,995 | 47722 | 51,494 | 51,789 | 1,446 | 41,489 |
| Total | 10,778,260 | 10,854,690 | 10,771,543 | 10,737,013 | 11,150,187 | 10,858,339 |

Table 6. Number of projected duck-use-days associated with each habitat within the Yazoo Study Area for the Action Alternative.

| | Action Alternative-Total DUD (Nov-Feb) | | | | | |
|---|---|---|---|---|---|---|
| Habitat Type | 2015 | 2016 | 2017 | 2018 | 2019 | Average |
| Corn | 2,176 | 5,688 | 5,746 | 1,243 | 500 | 3,070 |
| Cotton | 0 | 0 | 0 | 0 | 0 | 0 |
| Forest-5% | 2,231,506 | 2,231,653 | 2,231,217 | 2,230,828 | 2,232,151 | 2,231,471 |
| Forest-10% | 1,769,142 | 1,769,499 | 1,761,083 | 1,761,995 | 1,771,997 | 1,766,743 |
| Forest-20+% | 5,283,667 | 5,305,905 | 5,256,652 | 5,194,767 | 5,080,472 | 5,224,293 |
| Milo | 165 | 14 | 43 | 0 | 0 | 44 |
| Open Water/Aquatic | 38,162 | 37,191 | 36,671 | 35,819 | 37,999 | 37,168 |
| Other | 0 | 0 | 0 | 0 | 0 | 0 |
| Rice | 403 | 408 | 56 | 931 | 129 | 385 |
| Scrub-shrub | 17,758 | 16,614 | 58,041 | 58,614 | 145 | 30,234 |
| SHM-Passively Managed | 43,007 | 83,170 | 31,124 | 60,273 | 653,690 | 174,253 |
| Soybeans | 54,381 | 48,638 | 51,068 | 51,913 | 1,242 | 41,448 |
| Total | 9,440,366 | 9,498,779 | 9,431,701 | 9,396,382 | 9,778,325 | 9,509,111 |

Table 7. Summary of area and foraging habitats that occur within the Yazoo Study Area before and after the implementation of the 14,000 cfs pump station.

| | No Action Alternative | | | Action Alternative | | | Reduction from No Action to Action Alternative | | |
|---|---|---|---|---|---|---|---|---|---|
| Habitat Type | Acres[a] | Hectares[a] | DUD | Acres[a] | Hectares[a] | DUD | Acres[a] | Hectares[a] | DUD/Year |
| Corn | 14 | 6 | 3,544 | 12 | 5 | 3,070 | -2 | -1 | -473 |
| Cotton | 4 | 2 | 0 | 3 | 1 | 0 | -1 | 0 | 0 |
| Forest-5% Canopy Gaps | 4,028 | 1,630 | 2,706,107 | 3,314 | 1,341 | 2,231,471 | -715 | -289 | -474,636 |
| Forest-10% Canopy Gaps | 3,029 | 1,226 | 2,132,043 | 2,502 | 1,013 | 1,766,743 | -526 | -213 | -365,299 |
| Forest-20+% Canopy Gaps | 7,438 | 3,010 | 5,706,724 | 6,792 | 2,749 | 5,224,293 | -647 | -262 | -482,432 |
| Milo | 0 | 0 | 59 | 0 | 0 | 44 | 0 | 0 | -14 |
| Open Water/Aquatic | 1,523 | 616 | 42,188 | 1,378 | 557 | 37,168 | -146 | -59 | -5,020 |
| Other | 200 | 81 | 0 | 177 | 72 | 0 | -23 | -9 | 0 |
| Rice | 3 | 1 | 450 | 3 | 1 | 385 | 0 | 0 | -64 |
| Scrub-shrub | 123 | 50 | 35,552 | 104 | 42 | 30,234 | -18 | -7 | -5,317 |
| SHM-Passively Managed | 291 | 118 | 190,184 | 266 | 108 | 174,253 | -25 | -10 | -15,931 |
| Soybeans | 506 | 205 | 41,489 | 504 | 204 | 41,448 | -2 | -1 | -41 |
| Total | 17,161 | 6,945 | 10,858,339 | 15,056 | 6,093 | 9,509,111 | -2,105 | -852 | -1,349,228 |

[a] Sum of acres across all months of the winter waterfowl period (November-February); therefore, not a true representation of actual acres at any given time but rather used to account for total DUDs over entire winter period.

Table 8. Acres projected to be flooded ≤ 18 inches in depth during the winter waterfowl period (November-February) within the Yazoo Study Area according to habitats within the 2018 NASS Cropscape land cover.

| | No Action Alternative (Acres) | | | | Action Alternative (Acres) | | | | Reduction from No Action to Action Alternative (Acres) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Habitat Type | Nov | Dec | Jan | Feb | Nov | Dec | Jan | Feb | Nov | Dec | Jan | Feb |
| Corn | 0 | 2 | 2 | 2 | 0 | 2 | 1 | 1 | 0 | 0 | 0 | 0 |
| Cotton | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| Forest-5% | 213 | 1,075 | 1,358 | 1,381 | 184 | 974 | 1,061 | 1,093 | -29 | -101 | -297 | -288 |
| Forest-10% | 143 | 854 | 1,004 | 1,020 | 121 | 784 | 775 | 815 | -22 | -70 | -229 | -205 |
| Forest-20+% | 372 | 2,259 | 2,396 | 2,363 | 349 | 2,266 | 2,018 | 2,121 | -23 | 6 | -378 | -242 |
| Open Water/Aquatic | 84 | 473 | 457 | 456 | 78 | 469 | 377 | 403 | -6 | -4 | -80 | -53 |
| Other | 12 | 77 | 82 | 86 | 11 | 76 | 70 | 74 | -1 | -2 | -12 | -12 |
| Rice | 1 | 3 | 2 | 2 | 0 | 3 | 2 | 2 | 0 | 0 | 0 | 0 |
| Scrub-shrub | 13 | 65 | 86 | 79 | 12 | 60 | 66 | 65 | -1 | -5 | -20 | -14 |
| SHM-Passively Managed | 6 | 36 | 32 | 32 | 5 | 32 | 27 | 28 | -1 | -4 | -5 | -4 |
| Soybeans | 32 | 203 | 197 | 199 | 32 | 212 | 188 | 199 | -1 | 8 | -8 | 0 |
| Total | 877 | 5,048 | 5,616 | 5,620 | 792 | 4,877 | 4,586 | 4,801 | -85 | -171 | -1,030 | -819 |

Table 9. The average number of acres across the POR that are flooded ≤ 18 inches in depth and available for feeding by waterfowl. Acres are defined according to the Hydrologic Unit Codes (HUC).

| | No Action Alternative (Acres) | | | | Action Alternative (Acres) | | | | Reduction from No Action to Action Alternative (Acres) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HUC | Nov | Dec | Jan | Feb | Nov | Dec | Jan | Feb | Nov | Dec | Jan | Feb |
| Little Callao | 33 | 93 | 54 | 59 | 32 | 92 | 53 | 59 | -1 | -1 | -1 | -1 |
| Anguilla | 84 | 768 | 286 | 328 | 72 | 740 | 244 | 300 | -12 | -27 | -42 | -28 |
| Holly Bluff | 51 | 710 | 559 | 517 | 41 | 659 | 326 | 432 | -10 | -51 | -233 | -85 |
| Lower Sunflower | 319 | 1,824 | 2,651 | 2,870 | 267 | 1,793 | 2,293 | 2,369 | -52 | -31 | -358 | -501 |
| Grace | 91 | 192 | 168 | 156 | 91 | 174 | 147 | 140 | 0 | -18 | -20 | -16 |
| Steele Bayou | 298 | 1,462 | 1,898 | 1,690 | 288 | 1,419 | 1,522 | 1,502 | -11 | -42 | -376 | -188 |
| Total | 877 | 5,048 | 5,616 | 5,620 | 792 | 4,877 | 4,586 | 4,801 | -85 | -171 | -1,030 | -819 |

## FIGURES

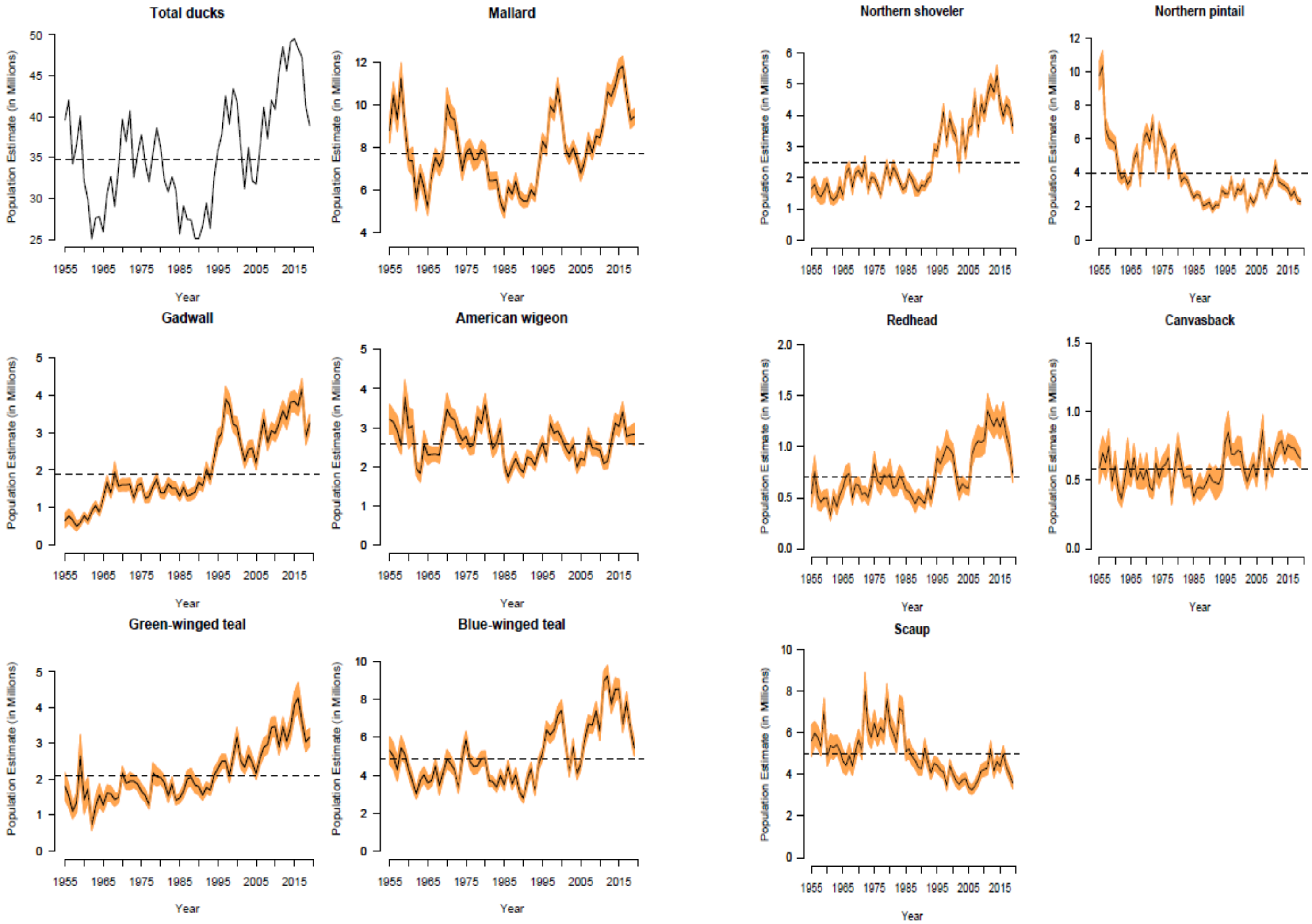


Figure 1. Breeding populations estimates for species of dabbling ducks from the period 1955-2019. Population estimate (in millions) on the vertical axis and survey year on the horizontal axis. Original figures obtained from the Waterfowl Population Status, 2019 Report (USFWS 2019).

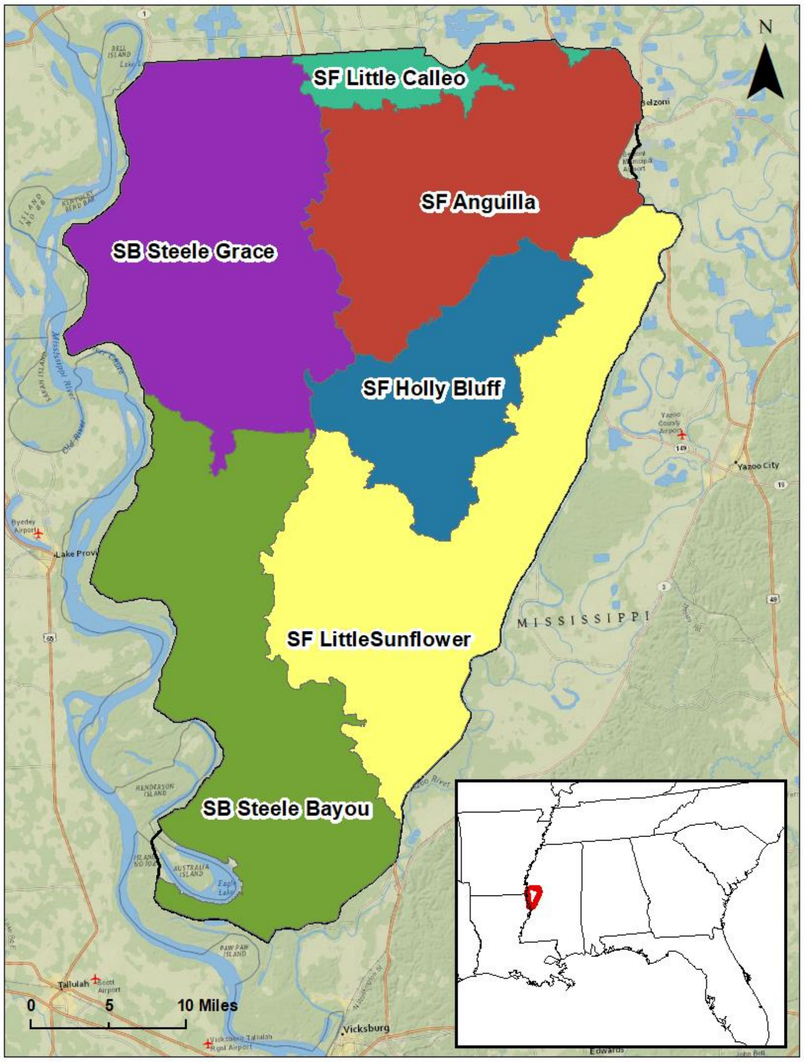


Figure 2. The six HUCs within the Yazoo Study Area used to calculate flooded acreages within the Enviro-Duck program.

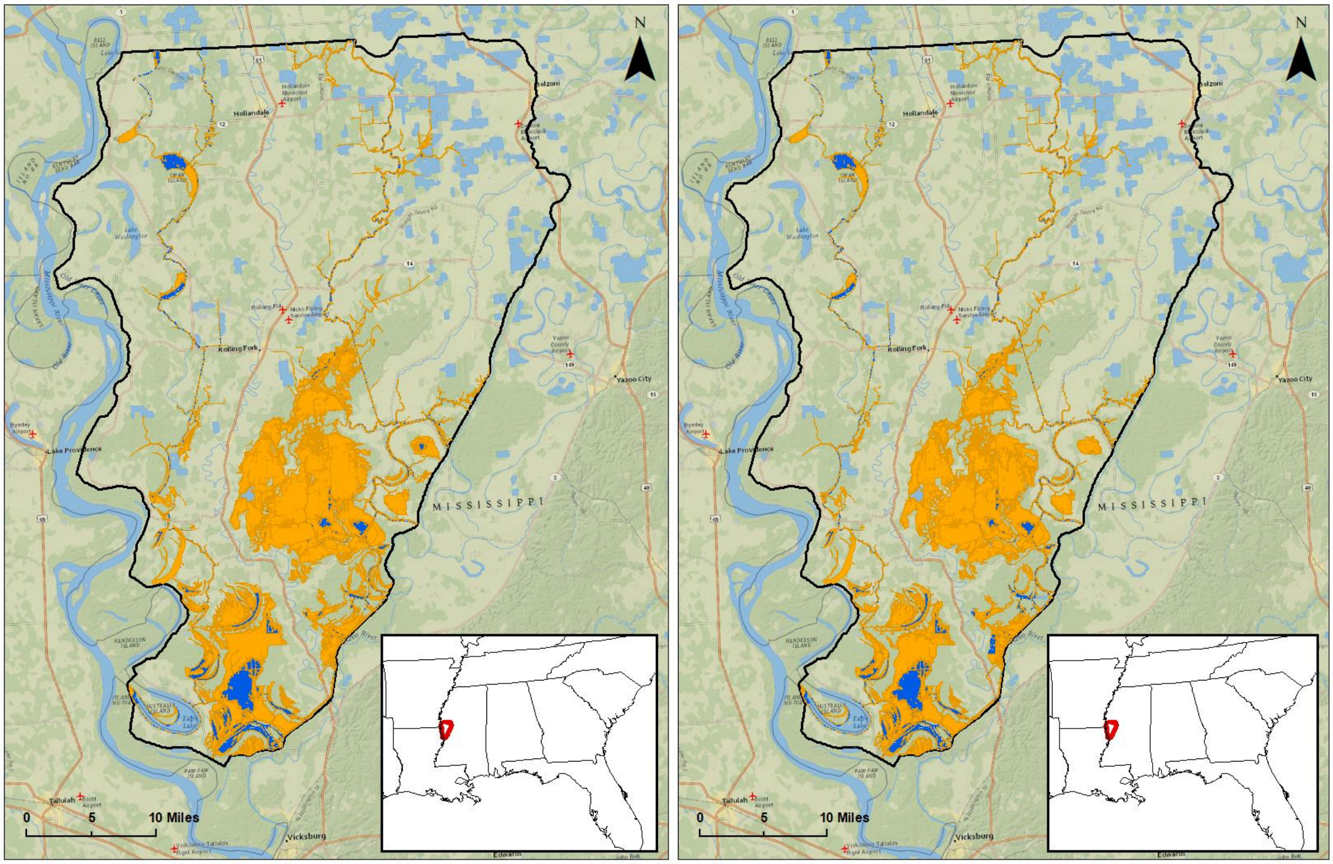


Figure 3. Areas expected to be inundated according to the 75th (blue) and 90th (orange) percentile for the hydrological POR for the No Action Alternative (left) and the Action Alternative (right).

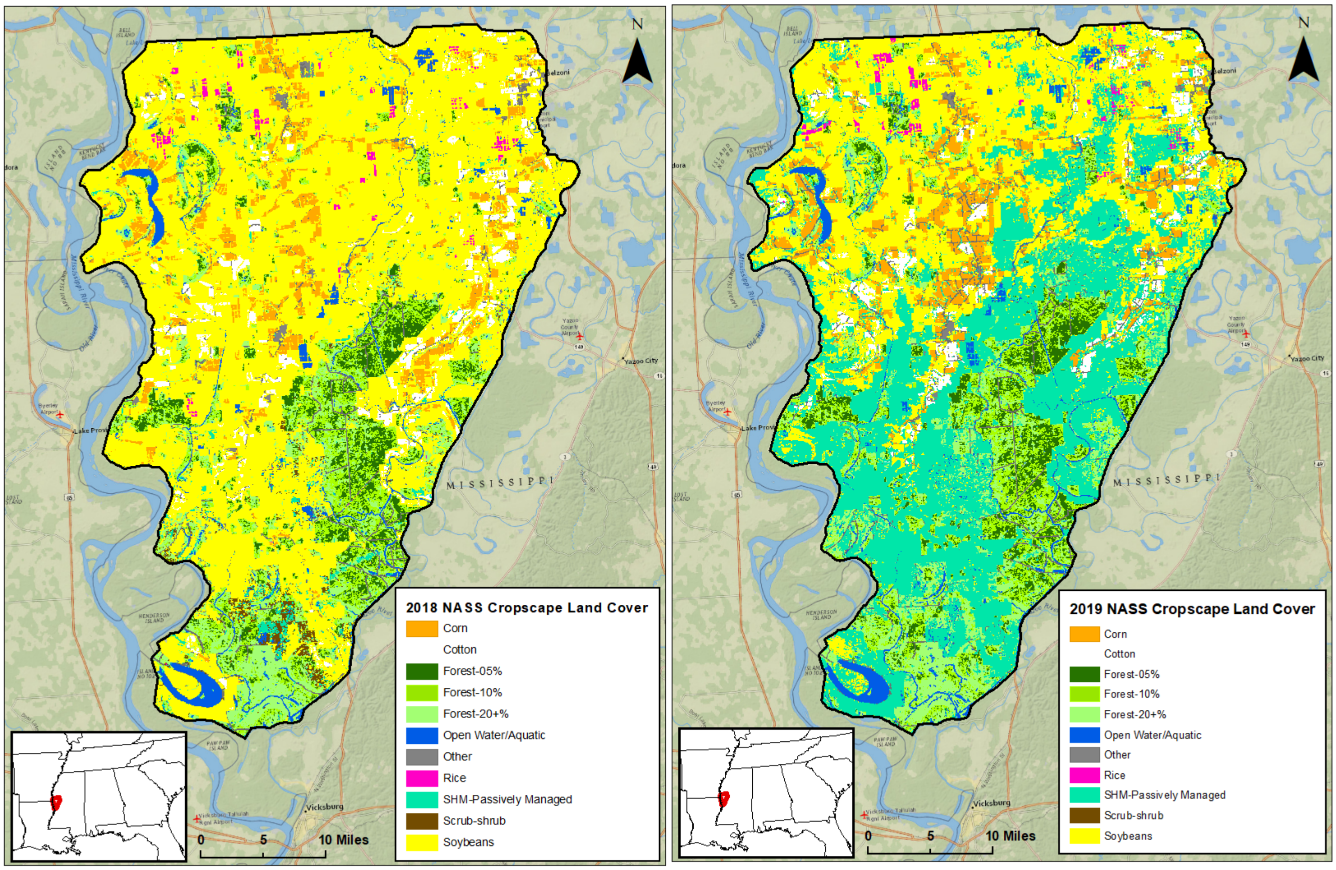


Figure 4. Comparison of land cover use between years with average precipitation/flooding (2018; left) and higher levels of precipitation/flooding during the growing season (2019; right).

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