AN EVALUATION OF CHANGES IN TERRESTRIAL HABITATS RESULTING FROM THE YAZOO BACKWATER PROJECT, MISSISSIPPI

by

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September 2006

Prepared for:

US Army Engineer District, Vicksburg
Vicksburg, MS 39180

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PREFACE

The US Army Engineer District, Vicksburg (CEMVK), has been authorized to provide flood protection through a series of projects in the Yazoo River Basin in northwestern Mississippi. This report contains an analysis of changes in the availability of habitats for terrestrial wildlife species resulting from construction and operation of the Yazoo Backwater Project (YBP). This report supersedes the March 2000 report.

This work involved the use of the US Fish and Wildlife Service (FWS) Habitat Evaluation Procedures (HEP), and was accomplished in cooperation with the 2000 terrestrial HEP Team: Messrs. Ken Quackenbush, FWS; Don Brazil, Mississippi Department of Wildlife, Fisheries, and Parks; and Gary Young, CEMVK. Updated hydrologic data and new project alternatives were provided by Messrs. Marvin Cannon, Gary Young, Basil Arthur, Dave Johnson, and others at CEMVK. Mr. Dwayne Templet and others from Geo-Marine, Inc., accomplished the field sampling.

During the conduct of this study, Dr. Morris Mauney was Chief of the Wetlands and Coastal Ecology Branch in the Environmental Laboratory (EL) of the US Army Engineer Research and Development Center (ERDC). At the time of completion, Dr. David Tazik was Chief, Ecosystem Evaluation and Engineering Division; and Dr. Beth Fleming was Director, EL. Dr. James Houston was Director and COL James Rowan was Commander of ERDC.

ABSTRACT

The US Fish and Wildlife Service Habitat Evaluation Procedures (HEP) were used to quantify anticipated impacts and benefits of the Yazoo Backwater Project (YBP) to terrestrial wildlife habitats in northwestern Mississippi. Six evaluation species – barred owl, gray squirrel, Carolina chickadee, pileated woodpecker, wood duck, and mink – were used to represent the habitat requirements of wildlife inhabiting the forested portions of the study area. The quality of habitat for each species was determined by measuring specific habitat variables (e.g., canopy cover, tree height, size and abundance of snags) on sample plots and entering these data into Habitat Suitability Index (HSI) models for each species. HSI scores can range from 0 (unsuitable habitat) to 1.0 (optimal habitat). Hydrologic information required by the models was provided by the Vicksburg District, US Army Corps of Engineers.

The study area consisted of the designated Steele Bayou Lower Ponding Area and Little Sunflower Upper Ponding Area in Humphreys, Issaquena, Sharkey, Warren, Washington, and Yazoo Counties, Mississippi, and Madison Parish, Louisiana. Impacts and benefits were estimated for no action, four nonstructural, and five structural alternatives. Separate analyses were performed for each area and alternative plan. In addition, two project scenarios were evaluated. Scenario B1 assumed that the Big Sunflower River Maintenance Project (BSRMP) had not been implemented and, therefore, did not influence the hydrology of the YBP study area. Scenario B2 assumed that the BSRMP was completed and influenced the YBP area.

Baseline (pre-project) HSI values indicated better-than-average habitat quality for most evaluation species. HSI values in the two areas ranged from 0.70-0.82 for barred owls, 0.58-0.62 for gray squirrels, 0.65-0.71 for Carolina chickadees, 0.79-0.86 for pileated woodpeckers, 0.45-0.58 for wood ducks, and 0.11-0.12 for mink. The HSI for wood ducks applies only to forest that is flooded continuously during the brood-rearing period, assumed to be March through May in this area. The HSI for mink applies only to areas of potential mink habitat, defined as forest land that is flooded at least 25% of the year (cumulative duration). The very low HSIs for mink were due to average annual flooding durations on these lands that barely exceeded the 25% minimum specified in the model.

Effects of each project plan were determined by calculating the net change in Average Annual Habitat Units (AAHU) between the no-action alternative (Plan 1) and each with-project plan for each evaluation species. When the reforestation component of several plans was not considered, only the structural plans (Plans 3, 4, 5, 6, and 7) and Plan 2B showed any effects on wildlife habitats. Changes in habitat availability were due to the clearing 38 acres of existing mature forest at the pump site in the Lower Ponding Area and water-management practices that affected the two water-dependent species, wood duck and mink. Results were nearly identical under the two scenarios. Therefore, the effects of the YBP on the availability of wildlife habitat were not affected appreciably by whether or not the BSRMP was implemented first.

When the overall effects of project construction, operation, and reforestation were considered, only Plan 3, which lacked a reforestation component, had overall negative effects on wildlife habitat availability, with the loss of approximately 113 AAHU for all six species combined. Plan 7 would produce the greatest overall benefits to wildlife, with a gain of 194,313

AAHU. Plan 2 was nearly as great, with a gain of 194,064 AAHU. In descending order, habitat gains for the remaining plans were 178,464 AAHU for Plan 2C, 127,233 AAHU for Plan 6, 126,984 AAHU for Plan 2A, 86,862 AAHU for Plan 5, 58,158 AAHU for Plan 4, and 37,283 AAHU for Plan 2B. Reforestation of existing cleared land would provide even greater benefits if some tracts were located within 328 ft of a semipermanent stream or lake, which would provide greater benefits to wood ducks and mink.

AN EVALUATION OF CHANGES IN TERRESTRIAL HABITATS RESULTING FROM THE YAZOO BACKWATER PROJECT, MISSISSIPPI

PART I: INTRODUCTION

Background and Objectives

This report is one of a series of studies of the potential impacts and benefits to terrestrial wildlife habitats of the reformulated Yazoo Basin flood control projects in northwestern Mississippi. This report contains an analysis of changes in the availability of habitats for terrestrial wildlife species resulting from construction and operation of the Yazoo Backwater Project (YBP). Previous reports addressed the Steele Bayou project (Wakeley and Marchi 1991), maintenance and operation of reservoir outlet channels (Wakeley 1991), the Upper Yazoo Project (Wakeley and Marchi 1992), the Mississippi Delta Project (Wakeley 1996), and the Big Sunflower River Maintenance Project (Wakeley 2004).

As in the previous analyses, the Habitat Evaluation Procedures (HEP) (US Fish and Wildlife Service 1980a, b) were used to quantify the potential impacts and benefits of various project alternatives to terrestrial wildlife species inhabiting forested habitats in the Yazoo Backwater Project (YBP) area. HEP is a habitat-based evaluation system that allows one to estimate current habitat conditions, predict future conditions, compare project alternatives, and devise mitigation strategies, all without the need for direct sampling of animal populations.

The objectives of this work were (1) to determine baseline (pre-project) habitat suitability for selected wildlife species in the YBP study area, and (2) to estimate changes in habitat availability for each species under each project plan. The YBP differed from previous projects in the Yazoo Basin in that design features intended to benefit wildlife species (e.g., reforestation of existing cleared land) were an integral part of most project plans. Therefore, the purpose of this study was to evaluate the overall effects of each plan on wildlife habitat. Potential mitigation options also were outlined in this report.

An Overview of HEP

HEP is an accounting system for quantifying and displaying habitat availability for fish and wildlife. HEP is based on habitat suitability index (HSI) models that quantitatively describe the habitat requirements of a species or group of species. HSI models use measurements of appropriate variables to rate the habitat on a scale of zero (unsuitable) to 1.0 (optimal). In a typical HEP study, a number of evaluation species are chosen for each cover type of interest in the study area. Species may be chosen because of their ecological, recreational, or economic value, or because they represent groups of species (i.e., guilds) that have similar habitat needs (Roberts and O’Neil 1985).

After cover types in the study area have been mapped and evaluation species have been selected, habitat variables contained in the HSI models for each species are measured from maps, aerial photographs, or by onsite sampling. HSI values are then calculated, and the initial or baseline number of habitat units (HUs) is determined for each species. One HU is equivalent to 1 acre of optimal habitat; therefore, the number of HUs for a species is calculated as the number of acres of available habitat times its suitability (HU = HSI × acres).

HUs available to each species are estimated for each of several target years (TYs) over the specified life of the project (generally 50 years after project completion) plus any pre-project construction period. Estimates of future habitat conditions are made for the "without project" alternative and for each "with project" alternative. Habitat availability for each species under each alternative over the life of the project is determined by accumulating the number of HUs available each year and dividing by the life of the project (in a procedure called annualization) to calculate Average Annual Habitat Units (AAHUs). Impacts or benefits to each species are then determined by calculating the difference in AAHUs between with-project and without-project alternatives. (The preceding information was adapted from Wakeley and O'Neil 1988).

PART II: STUDY AREA AND METHODS

The HEP Team

The function of a "HEP Team" is to guide the evaluation, monitor its progress, examine intermediate results, and make changes in direction, if needed. The terrestrial HEP Team was assembled in 1994 for an earlier analysis of YBP alternatives. The Team consisted of Mr. Ken Quackenbush (US Fish and Wildlife Service) (FWS), Mr. Don Brazil (Mississippi Department of Wildlife, Fisheries, and Parks) (MDWFP), and Mr. Gary Young (US Army Corps of Engineers, Vicksburg District) (CEMVK). Other participants in HEP Team meetings included Messrs. Steve Reed, Charlie McKinnie, and Marty Garton (CEMVK), and Mr. Dwayne Templet of Geo-Marine, Inc. For the current analysis, updated hydrologic and environmental information was provided by Messrs. Marvin Cannon, Basil Arthur, Dave Johnson, and others at CEMVK.

Study Area

The study area for the YBP was located in Humphreys, Issaquena, Sharkey, Warren, Washington, and Yazoo Counties, Mississippi, and Madison Parish, Louisiana. Large portions of the area are subject to backwater flooding from Steele Bayou, Deer Creek, and the Big and Little Sunflower Rivers at times when Mississippi River levels are high and drainage of the area through the Steele Bayou structure is not possible. The study area was divided into two components: the Steele Bayou Lower Ponding Area and the Little Sunflower Upper Ponding Area (see the Engineering Appendix, Appendix 6, for a map of the study area). These areas are denoted as the Lower Ponding Area and Upper Ponding Area in the rest of this report.

Project Alternatives

Alternative project plans are described in detail in the Engineering Appendix (Appendix 6) and are summarized briefly here (Table 1). Plan 1 is the no-action alternative and consists of the continuation of existing or baseline habitat conditions. Plans 2, 2A, 2B, and 2C are nonstructural plans involving reforestation of existing frequently flooded croplands and no pump station at the Steele Bayou structure. However, Plan 2B also would provide 100-year flood protection to certain areas by constructing 14 ring levees around important structures in the study area. Plans 3 through 7 involve the installation and maintenance of a 14,000 cubic-ft/sec (cfs) pump station to evacuate flood water over the main levee at Steele Bayou, and each of these plans could potentially involve both construction and hydrologic impacts to wildlife. Under each structural plan, 38 acres of existing mature forest would be cleared at the site of the pumping station. In addition, those plans would alter flooding frequency and duration over wide areas, with potential effects on water-dependent wildlife species. Plans 4, 5, 6, and 7 also include the reforestation of varying amounts of existing frequently flooded cropland. Potential effects of each project plan on the availability of wildlife habitat in the study area were determined by comparing each active plan (i.e., Plans 2, 2A, 2B, 2C, 3, 4, 5, 6, and 7) against the no-action alternative (Plan 1).

Cover Types

The YBP area consists largely of agricultural land containing scattered remnants of the original bottomland hardwood and cypress/tupelo forests. Two of the largest remaining blocks of forest in the study area are the Delta National Forest and adjacent forested lands in the Upper Ponding Area, and the Mahannah tract at the southern end of the Lower Ponding Area.

Agricultural areas in the YBP were considered to have little value as wildlife habitat, except for fields that are flooded during the winter and attract large numbers of waterfowl (see the separate analysis of project impacts and benefits for wintering waterfowl). Therefore, the terrestrial habitat evaluation was limited to forested habitats.

According to CEMVK, more than 85% of forest acreage in the YBP was in bottomland hardwoods (BLH) with the remainder in cypress/tupelo stands. However, when examined on the ground, cypress/tupelo stands rarely were large enough or stocked densely enough to sample. Many stands were no more than narrow fringes along creeks and lake margins. Because of these problems, cypress/tupelo was not included as a separate cover type in the HEP analysis. Therefore, BLH and cypress/tupelo were combined into a single "forested" cover type and the wildlife value of each component was assumed to be the same.

Evaluation Species

Species used in the YBP analysis were selected to reflect the wildlife values of the relatively mature forests existing in the basin. Four species – barred owl (*Strix varia*), gray squirrel (*Sciurus carolinensis*), Carolina chickadee (*Parus carolinensis*), and pileated woodpecker (*Dryocopus pileatus*) – inhabit upland forests and forested wetlands. Barred owls and pileated woodpeckers prefer mature forests with closed canopies and large trees. Woodpeckers excavate nesting cavities in live trees or snags, and owls use pre-existing cavities. Carolina chickadees nest in small cavities and forage in closed forests with abundant tree foliage. Gray squirrels prefer mature forest with dense understory vegetation and abundant mast-bearing trees such as oaks (*Quercus* spp.) and hickories (*Carya* spp.).

The remaining two species – wood duck (*Aix sponsa*) and mink (*Mustela vison*) – also inhabit forested areas but require the presence of surface water for at least part of the year. Wood ducks build their nests in large cavities in live trees or snags, or will use artificial nest boxes, if present. Brood-rearing habitat consists of areas that are flooded continuously during spring and have abundant cover near the water's surface. Mink inhabit wooded swamps and upland forests adjacent to lakes and streams. Much of their diet consists of fish and aquatic invertebrates, although they also capture birds, small mammals, reptiles, and amphibians.

Habitat Suitability Index Models

Published HSI models, developed by FWS, were available for five of the evaluation species – barred owl (Allen 1987a), gray squirrel (Allen 1987b), pileated woodpecker (Schroeder 1983a), wood duck (Sousa and Farmer 1983), and mink (Allen 1986). The wood duck model contained two parts, a breeding model and a wintering model. Only the breeding model was used in this analysis. For the mink, only the version of the model for palustrine forested wetlands was appropriate to the study area and to the kinds of impacts anticipated in this project. A model for the Carolina chickadee was developed for this study by Rick Schroeder (US Geological Survey, Biological Resources Division (BRD), Fort Collins, CO; letter from Adrian Farmer, BRD, to Robert Barkley, USFWS, Vicksburg, MS, dated 29 October 1989). The model was based on an existing HSI model for the black-capped chickadee (*Parus atricapillus*) (Schroeder 1983b). Habitat variables used in the six HSI models are listed in Table 2.

With the concurrence of the original Steele Bayou Project HEP Team, minor modifications were made in some models to correct errors in the original published versions or to tailor the models to conditions expected in the Yazoo Basin (Wakeley and Marchi 1991). Furthermore, conventions regarding minimum suitable tract size and juxtaposition of habitat types developed for the Steele Bayou study (Wakeley and Marchi 1991) were followed in the YBP analysis. In general, habitat variables were measured in forested tracts ≥10 acres in size but results were applied to all stands ≥1 acre. Thus it was assumed that even small stands had habitat value. It was further assumed that forest tracts in this study area were in close enough proximity, and sufficient corridors for animal movements existed between them (e.g., along stream and ditch banks), that no species was limited by small tract size or unfavorable dispersal conditions. In applying the wood duck model, it was assumed that flooded forests provided both nesting sites (i.e., tree cavities) and brood-rearing habitat, eliminating the need to consider juxtaposition of habitat types that provided only one but not both life requisites.

Selection of Tracts to Sample

HEP analyses were performed separately for the Lower and Upper Ponding Areas. Therefore, the sampling scheme was designed to determine average habitat suitability of existing forested tracts within a given area.

Tracts to be sampled in each area were selected according to procedures developed in previous studies (e.g., Wakeley and Marchi 1991, 1992). Maps showing the locations of forest stands were produced by CEMVK on the GIS at a scale of 1:62,500. Individual forest tracts were circled and numbered consecutively. For sampling purposes, tracts were defined as blocks of forest at least 10 acres in size separated from other such blocks by at least 82 ft (25 m). Some large tracts were subjectively divided at major constrictions and the parts numbered separately.

To identify tracts to sample, tract numbers were selected from a table of random numbers. In the field, the sampling teams had the prerogative to drop a tract from the sampling list if (1) it did not meet the Society of American Foresters definition of a forest (i.e., at least 25% canopy cover of trees), (2) it was highly urbanized, (3) it was a linear stand less than 328 ft wide, or (4) permission for access could not be obtained. In such cases, an additional randomly selected tract in that area was substituted. Eight tracts were sampled in 1994 in the Lower Ponding Area and 28 in the Upper Ponding Area.

In addition, sample sizes were augmented with data from several tracts sampled in previous Yazoo Basin studies that fell within YBP boundaries. Data from eight tracts sampled in 1990 during the Steele Bayou Project were included in the Lower Ponding Area (total $n = 16$ tracts), and data from four tracts sampled in 1993 during the initial Big Sunflower River Maintenance Project were added to the Upper Ponding Area (total $n = 32$ tracts). Tracts consisted of relatively mature forest stands at the time of sampling in 1990 to 1994. It was assumed that these data adequately reflect current baseline conditions.

Estimating Habitat Variables and Affected Acres

Sampling Teams

Habitat variables contained in the HSI models were measured during August and September 1994 by sampling teams from Geo-Marine, Inc., Baton Rouge, LA. Some of the field personnel had also participated in previous Yazoo Basin field studies, insuring consistency in data collection.

Number and Location of Plots

As in previous studies, habitat variables were measured within nested 0.1 and 0.2-acre circular sampling plots established at intervals along one or more transects in each selected forest tract. Whenever possible, transect starting points and directions were determined by stopping at a randomly selected point along a road or accessible edge of the tract, and using the topographic map to determine a compass bearing along the expected moisture gradient. This sampling scheme was designed to (1) include the range of moisture conditions in the tract, (2) include both BLH and cypress stands, if present, and (3) include any areas that typically contain standing water. If the tract was large or heterogeneous, one or more additional transects were established; however, most tracts contained only one transect.

The center of the first sampling plot was established approximately 300 ft from the edge of the tract and subsequent plots generally were located at 300-ft intervals. Teams were free to modify plot spacing to adapt the sampling design to the site. Sampling continued until, in the sampling team's judgment, a sufficient number of plots had been sampled to characterize average conditions in the tract. Sampling teams were directed to sample at least three plots in each cover type, but to continue sampling if tracts were heterogeneous or changing along the gradient. Whenever the transect encountered a stream or lake, at least one additional plot was established at the water's edge to estimate certain variables used in the wood duck and mink models.

In all, 152 plots were used in the analysis, including those from previous studies. Forty nine plots were sampled in the Lower Ponding Area and 103 in the Upper Ponding Area.

Plot Sampling

Habitat variables (Table 2) were either estimated directly or calculated later from data collected in the field. Unless otherwise specified, all data were collected on a 37-ft radius (0.1-acre) plot.

The tree layer consisted of all woody plants >20 ft tall, excluding vines. Trees rooted in the plot were classified visually as either overstory (at least 80% of the height of the tallest tree) or understory, and identified to species. The diameter at breast height (DBH) of each tree was measured to the nearest inch, and the average height of all trees (TREEHT) was estimated visually and checked occasionally with a clinometer. Tree counts and DBH measurements were used to calculate the mean DBH of overstory trees (MEANDBH), density of trees >20 inches DBH (DENTR20), and the number of hard mast species ≥10 inches DBH (MASTSPEC). Oaks (*Quercus* spp.) and hickories (*Carya* spp.) were the only hard-mast genera in the study area.

To improve the accuracy and consistency of visual estimates of percent cover, each member of a sampling team would make an independent estimate, compare estimates with other team members, and arrive at a consensus. Percent cover was estimated separately for all trees (TREECOV), overstory trees (OVERCOV), emergent herbaceous vegetation (EMERGCOV), and potential wood duck brood cover (BROODCOV). The last two variables were measured at inundated or shoreline plots only. In addition, the proportion of tree canopy cover that consisted of hard-mast producers (MASTPROP), was calculated from TREECOV and an estimate of the canopy cover of hard-mast species ≥10 inches DBH.

The shrub layer consisted of woody plants 3-20 ft tall, including vines. Estimates were made of the percent cover of shrubs (SHRUBCOV) and of trees and shrubs combined (SHTRCOV).

The following data were collected within a 53-ft radius (0.2-acre) plot. STUMPLOG was the combined number of tree stumps (>1 ft tall and >7 inches in diameter) and logs (>7 inches in diameter at the large end and >3 ft long) in the plot. CAVITY was the number of living trees with cavities >1 inch in diameter, found in the trunk or limbs >4 inches in diameter. WDCAVITY was the number of cavities at least 3 by 4 inches in opening size found in trees or snags ≥6 ft above the ground, and WDBOXES was a count of existing maintained and predator-proof nesting boxes designed for wood ducks.

Snags were defined as standing dead trees >4 inches in diameter and ≥6 ft tall, including live trees from which >50% of the branches had fallen or were present but no longer produced foliage. DBH measurements of all snags in the plot were used to calculate the density of snags >4 inches DBH (DENSN4), density of snags >15 inches DBH (DENSN15), mean DBH of snags >15 inches DBH (AVGSN15), and the combined density of trees and snags >20 inches DBH (TRSN20).

Affected Acres

CEMVK provided the data needed to quantify the effects of each project plan under two different project scenarios. The first scenario, identified as "B1" in this document, assumes that the Big Sunflower River Maintenance Project (BSRMP) has not been implemented and, therefore, has no hydrologic influence on the YBP study area. The second scenario, identified as "B2," assumes that the BSRMP has been completed and affects the hydrology of the YBP study area.

Construction impacts of the YBP were limited to the 38 acres of forest clearing required to establish the pumping station under Plans 3, 4, 5, 6, and 7. The impacted area is not flooded for long periods each year under existing conditions; therefore, the clearing of these acres would affect only barred owls, gray squirrels, Carolina chickadees, and pileated woodpeckers among the six evaluation species. The amount of forest clearing required under each plan is the same under scenarios B1 and B2.

The nonstructural plans and four of the structural plans would involve reforestation of varying amounts of existing frequently flooded cropland. Anticipated acreages of reforestation were provided by CEMVK (Table 1). Location of the lands subject to reforestation was not yet known. Therefore, for purposes of this analysis, the anticipated acreage was split equally between the two ponding areas. The per acre value of reforestation is not dependent on the location of the reforestation tracts.

The wood duck HSI model was applied only to areas that were potential brood habitat, defined as forest that is flooded continuously every year during the brood-rearing period (assumed to be March through May). Estimates of the average number of acres of wood duck brood habitat in each area under each structural plan (including Plan 2B) and scenario were provided by CEMVK (Table 3). The other nonstructural plans, which do not involve water management, would not affect existing wood duck or mink habitat.

The mink model for forested wetlands required estimates of the number of acres of forest that have surface water present for at least 25% of the year (cumulative duration) at 2-year frequency, plus estimates of the average flooding duration (PCTYEAR) in those areas. CEMVK hydraulics staff provided the estimates under each structural plan (including Plan 2B) and scenario (Table 4).

Calculating Baseline Habitat Conditions

The Statistical Analysis System (SAS) (SAS Institute, Inc. 1999) was used to calculate habitat variables from field data for each sampled plot. For most variables, plot values were first averaged within tracts and tract means were then averaged within areas. Standard errors, reflecting among-tract variance, were calculated for each variable. This procedure gave equal weight to the tracts in calculation of ponding-area means regardless of tract size; however, tract sizes had often been determined arbitrarily by splitting larger tracts to make sampling more efficient.

Averaging the number of hard-mast species (MASTSPEC) across plots underestimated the total number of mast species in a tract. Therefore, tract values were determined by counting species that were tallied in all plots in the tract.

To determine baseline (existing) habitat suitability, means of habitat variables for each area were entered into the HSI models for each evaluation species. To make data handling more efficient, HSI models were programmed in SAS. The SAS versions were checked against those provided by FWS with their HSI software by running sample data sets and comparing output.

Estimating Effects of Hydrologic Change

For the two water-dependent species – wood duck and mink – the impacts of altered hydrology could be evaluated directly from estimates of pre- and post-project flooded acres and flood durations provided by CEMVK. For the remaining evaluation species, however, effects of project-induced changes in hydrology included the potential for long-term changes in forest structure or species composition. Two approaches were used to evaluate those effects: (1) gathering opinions from experts and (2) simulating forest growth in relation to hydrology.

Workshop of Experts

On 2 April 1990, a workshop was convened at the Waterways Experiment Station (WES) to consider approaches to predicting future forest conditions in the Yazoo Basin as a result of proposed flood control projects. Workshop participants were Mr. Steve Meadows, US Forest Service Southern Hardwoods Laboratory, Stoneville, MS; Mr. Adrian Farmer, USGS Biological Resources Division, Fort Collins, CO; Mr. Will Conner, Belle Baruch Institute of Clemson University, Georgetown, SC; Drs. Jean O'Neil and Charles Klimas, WES; and Mr. Jim Teaford, formerly of WES.

The consensus of workshop participants was that there were unlikely to be any significant changes in forest cover types or in overstory conditions during the 50-year economic life of the Yazoo Basin projects. Although changes in the understory were possible (i.e., changes in coverage and density of shrubs and herbaceous vegetation), the only anticipated effects on the tree layer were increased growth and productivity resulting from less frequent and shorter duration flooding. This conclusion is still thought to be valid. The participants further recommended that a bottomland hardwood succession model called FORFLO be used to provide more quantitative predictions of forest changes under altered hydrologic regimes.

FORFLO Simulation

FORFLO (Pearlstine et al. 1985, Pearlstine 1985) was developed by the USGS National Wetlands Research Center. It simulates the growth of individual trees on a 0.2-acre plot as influenced by hydrologic regime and interactions with other species. FORFLO was used to predict forest succession on areas subject to altered hydrology in the Yazoo Basin.

Standard inputs to this stochastic model include the species, diameters, and densities of trees on the plot; biweekly means and standard deviations of flood-water surface elevations throughout the year; ground surface elevation; average growing-season water-table depth; and soil type. Standard outputs include annual flood duration; average flood height; density, basal area, and frequency of tree species on the plot by diameter category (<10 inches and >10 inches DBH); total canopy closure; and canopy closure of mast-bearing trees. Simulated plot data are displayed at 10-year intervals.

Although FORFLO simulates growth of trees on a small plot, the HEP focused on average conditions within forest tracts. Therefore, data from sample plots within a tract were first averaged (by cover type) before they were entered into FORFLO. With-project and without-project hydrologic data were provided by CEMVK for selected test sites within the Steele Bayou Basin, and soil data were taken from the appropriate published county soil survey. Additional FORFLO simulations were performed on hypothetical data that represented the extremes of hydrologic change expected in the basin.

The FORFLO model was modified slightly for this study. Estimates of MEANDBH, DENTR20, and TREEHT were produced in addition to the standard output. For the purpose of estimating MEANDBH, which considers only overstory trees, it was necessary to assume that any tree ≥6 inches DBH was an overstory tree. Modifications to the program and all FORFLO simulations were performed by Mr. James A. Allen, USGS National Wetlands Research Center, Lafayette, LA.

To evaluate effects of altered flooding regime on habitats for barred owls, gray squirrels, Carolina chickadees, and pileated woodpeckers, FORFLO was used to estimate future values of critical variables in their HSI models. Thus, values of MEANDBH, MASTPROP, TREEHT, and DENTR20 were predicted after either 50 years of continued pre-project hydrology (the without-project simulation) or 50 years under an estimated or hypothetical with-project flooding regime.

FORFLO Results

The FORFLO results supported the conclusions of the experts by confirming that the major effect of reduced flooding over the life of a project is slightly increased growth and productivity of trees. Therefore, MEANDBH, TREEHT, and DENTR20 tended to be greater after 50 years with drier conditions. These changes generally benefitted barred owls, Carolina chickadees, and pileated woodpeckers. Similarly, increased flooding would have a slight negative effect on habitat suitability for these species. The effects on mast-producing trees (MASTPROP), and therefore on gray squirrels, were less predictable but, on average, appeared to be neutral.

After reviewing these results, the HEP Team decided that hydrologic impacts to habitats for barred owls, gray squirrels, Carolina chickadees, and pileated woodpeckers would not be considered further in the impact analysis, although the Team recognized that small benefits and/or impacts may accrue to these species as a result of a project. However, any potential changes in habitat quality would likely be insignificant because most forest tracts in the study area would not experience the levels of hydrologic change that were simulated with FORFLO.

Analysis of Impacts

HEP software, provided by the USGS Biological Resources Division, Fort Collins, CO, was used to estimate impacts of project alternatives on habitat availability for the six evaluation species. Separate analyses were performed for each area.

Project Life and Period of Analysis

HEP requires that habitat availability for each species be estimated for each of several target years over a period of analysis that may include the economic life of the project plus any additional pre-project impact period during construction. For the YBP, construction will begin in 2008 and continue through 2011. It was assumed that the clearing of 38 acres of mature forest at the pump site would be done in 2008. The 50-year economic life of the project will begin in 2012 and end in 2062. Thus, the hydrologic effects of the project would start in 2012 when the pump begins operating. It was assumed that reforestation of existing cleared lands would begin in 2008. Therefore, by 2062 the reforested areas would have had the opportunity to grow and develop over a period of more than 50 years. To be comparable, all habitat impacts and benefits were annualized over the 50-year economic life of the project.

Calculating Average Annual Habitat Units

Overall effects of each project plan in each area were determined by calculating the net change in AAHUs between active plans (Plans 2, 2A, 2B, 2C, 3, 4, 5, 6, and 7) and the no-action plan (Plan 1) for each evaluation species. Land that was cleared during construction was assumed to remain in a cleared condition throughout the life of the project.

PART III: BASELINE HABITAT CONDITIONS

Habitat Variables and HSI Values

Within each area, the amount of variability in habitat measurements was generally quite low (Table 5), indicating that tracts were fairly uniform in age and structure. There were also only small differences in habitat characteristics between areas. Average tree heights (TREEHT) ranged from 59-63 ft and canopy cover (TREECOV) from 75-82%. Between 41-43% of canopy cover was of mast-bearing trees (MASTPROP). MEANDBH ranged from 12-15 inches. Densities of large trees (DENTR20) ranged from 8-10 per acre.

HSI values in the two areas ranged from 0.70-0.82 for barred owls, 0.58-0.62 for gray squirrels, 0.65-0.71 for Carolina chickadees, 0.79-0.86 for pileated woodpeckers, 0.45-0.58 for wood ducks, and 0.11-0.12 for mink (Table 6). Most HSI values ranged from 0.58-0.86, indicating better-than-average habitat quality for the evaluation species. One exception was the very low HSI for mink in forested wetlands, due to average flooding durations that barely exceeded the minimum 25% cumulative duration required for use of an area by mink.

As in previous analyses of Yazoo Basin flood control projects, HSI values for each species reflected the limiting influences of only one or two habitat variables in each model. The HSI value for barred owls tended to be dictated by MEANDBH; the value for gray squirrels was limited by MASTPROP; Carolina chickadee HSI was limited by TREEHT; pileated woodpecker HSI by DENTR20; wood duck HSI by either BROODCOV or WDCAVITY; and mink HSI by PCTYEAR.

PART IV: ANALYSIS OF PROJECT PLANS

Effects of a project plan on habitat availability for each evaluation species were determined by calculating the change in AAHUs between the no-action alternative (Plan 1) and each with-project plan. Results were calculated separately for each area (Lower and Upper) and scenario (B1 and B2). The effects of project construction and operation on habitat availability, not including reforestation of existing cleared lands, are shown in Table 7 for scenario B1 and Table 8 for scenario B2. AAHU values given in the tables were summarized from the HEP Form D results given in Appendix A. Negative values indicate net loss of AAHUs and positive values indicate net gains. No impacts were anticipated from any of the nonstructural plans except Plan 2B, which would reduce the availability of habitat for both wood ducks and mink. The structural alternatives, on the other hand, involved habitat losses for some species and habitat gains for others. The clearing of 38 acres in the Lower Ponding Area would decrease habitat availability for the four generalist species (barred owl, gray squirrel, Carolina chickadee, and pileated woodpecker). However, the effects of changed hydrology would generally benefit the wood duck and mink. Total change in AAHUs across all six evaluation species are shown in Tables 7 and 8. However, AAHU totals can be misleading when some evaluation species gain habitat while others lose.

The nonstructural plans (Plans 2, 2A, 2B, and 2C) and four of the structural plans (Plans 4, 5, 6, and 7) include reforestation of varying amounts of existing cleared land. The anticipated benefits of reforestation to each wildlife species are shown in Table 9 and were calculated using a generic management plan (MP 4) that assumes that none of the reforested acreage is flooded more than 25% of the year or is located within 328 ft of a lake or stream that contains water for more than 25% of the year. Under this conservative assumption, none of the reforested lands would provide habitat for wood ducks or mink. (See Part V for a full explanation of Generic Management Plans.) Other management plans that provide greater benefits, particularly to the water-dependent species, may be applicable to portions of the reforested area if they meet the hydrologic and other requirements of a particular management plan. Therefore, the AAHU benefits of reforestation shown in Table 9 are minimum values and could be increased with proper selection of tracts to reforest.

Overall effects of project alternatives, including effects of construction, operation, and reforestation, are shown in Table 10. Results for scenario B1 only are shown. Results were identical under scenario B2, except that habitat losses for mink under Plan 2B were slightly less. Therefore, the effects of the YBP on the availability of wildlife habitat were not affected appreciably by whether or not the BSRMP was implemented first.

Only Plan 3, involving construction and operation of a pumping plant but without any reforestation component, had overall negative effects on wildlife habitat availability, with the loss of approximately 113 AAHU for all six species combined. Plan 7 would produce the greatest overall benefits to wildlife, with a gain of 194,313 AAHU. Plan 2 was nearly as great, with a gain of 194,064 AAHU. In descending order, habitat gains for the remaining plans were 178,464 AAHU for Plan 2C, 127,233 AAHU for Plan 6, 126,984 AAHU for Plan 2A, 86,862 AAHU for Plan 5, 58,158 AAHU for Plan 4, and 37,283 AAHU for Plan 2B (Table 10).

PART V: EFFECTS OF REFORESTATION

Several YBP project plans incorporate reforestation of existing cleared land as a way to achieve wildlife habitat benefits while, at the same time, satisfying flood-damage-reduction objectives. The purpose of this section is to provide some generic management plans that can be used to estimate the benefits of forest reestablishment in a variety of situations. Forest reestablishment can be accomplished either by (1) promoting natural revegetation and succession or (2) planting selected tree species (reforestation). This section considers both options, and provides potential benefits to evaluation species on a per-unit-area basis.

The habitat benefits of establishing new forest vary with the characteristics of the site and may depend upon other features that must be provided at the same time. For example, the four generalist species – barred owl, gray squirrel, Carolina chickadee, and pileated woodpecker – will benefit over time from almost any forest establishment, if tracts are of sufficient size (tract sizes >10 acres are recommended, not counting narrow or fringe woods) and enough time is allowed for growth. Mink will use forested wetlands that are flooded >25% of the year, and also will benefit from the establishment of forest cover adjacent to streams or lakes, as long as shoreline vegetation is allowed to develop or other foraging cover is provided. Wood ducks require shallow surface water within the forest at least during the brood-rearing period, and have the additional requirement of secure nesting cavities.

Generic Management Plans

The HEP software was used to calculate AAHUs that could be gained by reestablishing bottomland hardwood forest on a hypothetical 100 acres of existing cleared land under various management plans (Table 11). Benefits of management plans were estimated for selected target years over the period of analysis using models developed by consensus of the Steele Bayou Project and Upper Yazoo Project HEP Teams (Figures 1-3; Wakeley and Marchi 1991, 1992). It was assumed that management plans would be implemented concurrently with YBP construction. The assumed initiation date was 2008, the initial year of project construction. Benefits of the management plans were annualized over 50 years to be comparable with estimates of project impacts.

In practice, the species composition of reestablished woods will depend on the existing hydrology and soil characteristics of the site. Although Table 11 was developed specifically for BLH, it is anticipated that actual forest replacement will involve a mix of species, including cypress.

Management Plans (MP) 1, 2, and 3 assume that the area is allowed to revegetate naturally with a mix of volunteer bottomland species, whereas MP 4, 5, and 6 involve active reforestation by planting primarily mast-bearing species (i.e., oaks and hickories). Within each category, plans differ according to the assumed flooding regime within the developing forest, or its proximity to a semipermanent stream or lake. Among the evaluation species, only gray squirrels show any added benefit from planting hard-mast tree species. In this analysis, however, gray squirrels represent a guild of species that would benefit from mast-tree plantings, including other rodents, white-tailed deer (*Odocoileus virginianus*), and wild turkeys (*Meleagris gallopavo*). Complete HEP Form C results are given in Appendix B.

MP 1 and MP 4 (Table 11) assume that the site is flooded cumulatively less than 25% of the year (<90 days) and is not located within 328 ft of a stream or lake containing surface water more than 90 days each year. Therefore, reestablishing forest cover on the site will benefit the generalist species – barred owls, gray squirrels, Carolina chickadees, and pileated woodpeckers – but will provide no habitat for either mink or breeding wood ducks. It probably would not be appropriate to rely solely on these management plans for any project that involves significant impacts to the water-dependent species. However, these MPs may be appropriate in some portions of a larger management area or if reforestation occurs on more than one site.

The remaining plans are applicable to management areas adjacent to streams or lakes that contain water for long periods each year. As long as dense shoreline cover is encouraged, these areas will provide added benefits to mink and wood ducks. These plans may also be applicable to existing cleared lands that flood for long periods each year. However, very long-duration flooding may actually reduce habitat value for the generalist forest species (barred owl, gray squirrel, Carolina chickadee, pileated woodpecker) and may prevent the establishment of a diverse and structurally complex forest.

MP 2 (natural succession) and MP 5 (reforestation) assume that the management area is within 328 ft of a stream or lake that contains surface water for exactly 6 months cumulatively each year including continuous inundation during the March-through-May wood duck brood-rearing period. If the adjacent water body contains water less than 6 months, the site would have somewhat less value to mink, whereas it would have greater value if water was present more than 6 months. Abundant streambank cover is required. The benefit to wood ducks depends upon the presence of abundant over-water brood cover, and adequate numbers of well-maintained, predator-proof nesting boxes. These plans may also be applicable to reforested wetlands that pond or flood shallowly for long periods each year as long as the growth and development of the young forest is not hindered.

The appropriate number of nest boxes should be determined empirically by erecting a number of boxes, monitoring their success, and adding more boxes as needed. The Fish and Wildlife Service (Robert Barkley, personal communication, 14 May 1992) recommends an initial nesting box density of 0.5 boxes/acre in tracts <100 acres, and 0.1 boxes/acre in tracts >100 acres. Regenerating forest areas lacking nest boxes would provide no AAHU for wood ducks unless a mature stand containing many natural cavities is immediately adjacent to the newly established forest.

MP 3 and MP 6 assume that the reforested area is within 328 ft of a stream or lake, that water is present more than 9 months each year including the March-to-May period, and that wood duck boxes are provided. Well-developed shoreline cover (for mink) and brood cover over the water (for wood ducks) are required.

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Table 1

Alternative Project Plans, Yazoo Backwater Project

Plan	Features	Reforestation of Existing Cleared Land (acres)
1	No Action	None
2	Nonstructural (no pump)	124,400
2A	Nonstructural	81,400
2B	Ring levees with structures and small pumps	26,400
2C	Nonstructural	114,400
3	14,000-cfs pump	None
4	14,000-cfs pump	37,200
5	14,000-cfs pump	55,600
6	14,000-cfs pump	81,400
7	14,000-cfs pump	124,400

Table 2

Names and Abbreviations of Habitat Variables
Used in the HSI Models

Variable	Definition	Evaluation Species[a]
AVGSN15	Mean DBH of snags >15 inches DBH	PW
BROODCOV	Percent of water surface covered by potential wood duck brood cover	WD
CAVITY	Number of living trees with cavities >1 inch in diameter per acre	CC
DENSN4	Density of snags >4 inches DBH per acre	CC
DENSN15	Density of snags >15 inches DBH per acre	PW
DENTR20	Density of trees >20 inches DBH per acre	PW
EMERGCOV	Percent cover of emergent herbaceous vegetation	MK
MASTPROP	Proportion of total tree canopy cover that is hard-mast producers >10 inches DBH	GS
MASTSPEC	Number of hard mast species >10 inches DBH on the plot (or in the tract)	GS
MEANDBH	Mean DBH of overstory trees	GS, BO
OVERCOV	Percent canopy cover of overstory trees	BO
PCTYEAR	Percent of year with surface water present	MK
SHORECOV	Percent shoreline cover	MK
SHRUBCOV	Percent cover of shrubs	MK
SHTRCOV	Percent cover of trees and shrubs combined within 328 ft of the water's edge	MK
STUMPLOG	Combined number of stumps and logs per acre	PW
TREECOV	Percent canopy cover of trees	MK, PW, GS, CC
TREEHT	Average height of all trees	CC
TRSN20	Density of trees and snags >20 inches DBH per acre	BO
WDCAVITY	Number of cavities ≥3×4 inches per acre	WD
WDBOXES	Number of maintained and predator-proof nest boxes for wood ducks per acre	WD

[a]Barred owl (BO), Carolina chickadee (CC), gray squirrel (GS), mink (MK), pileated woodpecker (PW), and wood duck (WD).

Table 3

Estimated Acres of Wood Duck Habitat
Under Each Structural Plan and Plan 2B, Yazoo Backwater Project

Project Plan Or Base Condition	Minimum Number of Acres of Forest Flooded Continuously Each Year from March through May			
	Scenario B1		Scenario B2	
	Lower Ponding Area	Upper Ponding Area	Lower Ponding Area	Upper Ponding Area
Base Condition	7,930	1,920	7,930	1,920
Plan 2B	3,660	1,015	3,660	1,015
Plan 3	7,930	1,920	7,930	1,920
Plan 4	8,210	2,070	8,210	2,070
Plan 5	8,210	2,070	8,210	2,070
Plan 6	8,210	2,070	8,210	2,070
Plan 7	8,210	2,070	8,210	2,070

Source of data: CEMVK Hydraulics Staff.

Table 4

Estimated Acres of Forested Wetland Habitat
Suitable for Mink Under Each Structural Plan and Plan 2B, Yazoo Backwater Project

Project Plan or Base Condition	Acres of Forest Flooded ≥90 Days (25% Duration) at 2-Year Frequency			
	Scenario B1		Scenario B2	
	Lower Ponding Area	Upper Ponding Area	Lower Ponding Area	Upper Ponding Area
Base Condition	8,410 (30%)[a]	4,550 (31%)	8,410 (30%)	4,390 (31%)
Plan 2B	3,780 (30%)	2,370 (31%)	3,870 (30%)	2,280 (31%)
Plan 3	8,410 (30%)	4,550 (31%)	8,410 (30%)	4,390 (31%)
Plan 4	8,410 (30%)	4,550 (31%)	8,410 (30%)	4,390 (31%)
Plan 5	8,410 (30%)	4,550 (31%)	8,410 (30%)	4,390 (31%)
Plan 6	9,030 (30%)	4,960 (31%)	9,030 (30%)	4,800 (31%)
Plan 7	9,030 (30%)	4,960 (31%)	9,030 (30%)	4,800 (31%)

[a] Estimated actual average cumulative flooding duration.
Source of data: CEMVK Hydraulics Staff.

Table 5

Means and Standard Errors of Habitat Variables, Yazoo Backwater Project

Variable	Lower Ponding Area		Upper Ponding Area	
	Mean	SE[a]	Mean	SE
TREEHT	58.77	2.70	63.09	2.78
TREECOV	82.36	2.68	75.07	3.07
OVERCOV	71.01	3.14	60.88	3.46
SHRUBCOV	38.23	3.77	34.63	3.79
SHTRCOV	89.47	2.29	86.10	1.87
EMERGCOV	9.50	3.65	1.91	0.87
BROODCOV	28.98	4.05	29.28	4.54
MASTPROP	0.41	0.07	0.43	0.07
STUMPLOG	37.14	7.94	19.51	3.79
CAVITY	16.69	3.00	11.08	2.35
WDCAVITY	5.26	0.92	4.13	1.06
WDBOXES	0.00	0.00	0.00	0.00
MEANDBH	12.45	0.71	15.15	1.31
DENTR20	7.92	1.95	9.87	2.67
DENSN4	8.20	1.11	5.95	1.26
AVGSN15	23.97	2.58	21.62	2.55
DENSN15	1.07	0.41	0.86	0.30
TRSN20	8.49	1.91	10.29	2.69
MASTSPEC	2.94	0.42	2.75	0.32

[a] Standard errors reflect variability among tracts.

Table 6

Calculated Baseline Habitat Suitability Index (HSI) Values for Forested Habitats, Yazoo Backwater Project

Project Area	Barred Owl	Gray Squirrel	Carolina Chickadee	Pileated Woodpecker	Wood Duck[a]	Mink[b]
Lower Ponding Area	0.70	0.58	0.65	0.79	0.58	0.11
Upper Ponding Area	0.82	0.62	0.71	0.86	0.45	0.12

[a] Wood duck HSI applies only to areas flooded from March through May each year (brood habitat).
[b] Mink HSI applies only to forests flooded >25% of the year at 2-year frequency.

Table 7

Effects of Plan Construction and Operation on Terrestrial Wildlife Habitats Without Reforestation Under Scenario B1, Yazoo Backwater Project

	Net Change in Average Annual Habitat Units (AAHU)						
Project Plan	Barred Owl	Gray Squirrel	Carolina Chickadee	Pileated Woodpecker	Wood Duck	Mink	Total
				Lower Ponding Area			
Plan 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 2A	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 2B	0.00	0.00	0.00	0.00	-2,575.66	-529.67	-3,105.33
Plan 2C	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 3	-28.99	-24.02	-26.92	-32.72	0.00	0.00	-112.65
Plan 4	-28.99	-24.02	-26.92	-32.72	168.90	0.00	56.25
Plan 5	-28.99	-24.02	-26.92	-32.72	168.90	0.00	56.25
Plan 6	-28.99	-24.02	-26.92	-32.72	168.90	70.93	127.18
Plan 7	-28.99	-24.02	-26.92	-32.72	168.90	70.93	127.18
				Upper Ponding Area			
Plan 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 2A	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 2B	0.00	0.00	0.00	0.00	-545.90	-249.39	-795.29
Plan 2C	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 4	0.00	0.00	0.00	0.00	70.20	0.00	70.20
Plan 5	0.00	0.00	0.00	0.00	70.20	0.00	70.20
Plan 6	0.00	0.00	0.00	0.00	70.20	51.17	121.37
Plan 7	0.00	0.00	0.00	0.00	70.20	51.17	121.37

Continued.

Table 7 concluded.

Project Plan	Barred Owl	Gray Squirrel	Carolina Chickadee	Pileated Woodpecker	Wood Duck	Mink	Total
	Net Change in Average Annual Habitat Units (AAHU)						
				Lower and Upper Ponding Areas Combined			
Plan 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 2A	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 2B	0.00	0.00	0.00	0.00	-3,121.56	-779.06	-3,900.62
Plan 2C	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 3	-28.99	-24.02	-26.92	-32.72	0.00	0.00	-112.65
Plan 4	-28.99	-24.02	-26.92	-32.72	239.10	0.00	126.45
Plan 5	-28.99	-24.02	-26.92	-32.72	239.10	0.00	126.45
Plan 6	-28.99	-24.02	-26.92	-32.72	239.10	122.10	248.55
Plan 7	-28.99	-24.02	-26.92	-32.72	239.10	122.10	248.55

Table 8

Effects of Plan Construction and Operation on Terrestrial Wildlife Habitats Without Reforestation Under Scenario B2, Yazoo Backwater Project

	Net Change in Average Annual Habitat Units (AAHU)						
Project Plan	Barred Owl	Gray Squirrel	Carolina Chickadee	Pileated Woodpecker	Wood Duck	Mink	Total
Lower Ponding Area							
Plan 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 2A	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 2B	0.00	0.00	0.00	0.00	-2,575.66	-519.38	-3,095.04
Plan 2C	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 3	-28.99	-24.02	-26.92	-32.72	0.00	0.00	-112.65
Plan 4	-28.99	-24.02	-26.92	-32.72	168.90	0.00	56.25
Plan 5	-28.99	-24.02	-26.92	-32.72	168.90	0.00	56.25
Plan 6	-28.99	-24.02	-26.92	-32.72	168.90	70.93	127.18
Plan 7	-28.99	-24.02	-26.92	-32.72	168.90	70.93	127.18
Upper Ponding Area							
Plan 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 2A	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 2B	0.00	0.00	0.00	0.00	-545.90	-241.38	-787.28
Plan 2C	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 4	0.00	0.00	0.00	0.00	70.20	0.00	70.20
Plan 5	0.00	0.00	0.00	0.00	70.20	0.00	70.20
Plan 6	0.00	0.00	0.00	0.00	70.20	51.17	121.37
Plan 7	0.00	0.00	0.00	0.00	70.20	51.17	121.37

Continued.

Table 8 concluded.

Project Plan	Net Change in Average Annual Habitat Units (AAHU) Barred Owl	Gray Squirrel	Carolina Chickadee	Pileated Woodpecker	Wood Duck	Mink	Total
Lower and Upper Ponding Areas Combined							
Plan 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 2A	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 2B	0.00	0.00	0.00	0.00	-3,121.56	-760.76	-3,882.32
Plan 2C	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 3	-28.99	-24.02	-26.92	-32.72	0.00	0.00	-112.65
Plan 4	-28.99	-24.02	-26.92	-32.72	239.10	0.00	126.45
Plan 5	-28.99	-24.02	-26.92	-32.72	239.10	0.00	126.45
Plan 6	-28.99	-24.02	-26.92	-32.72	239.10	122.10	248.55
Plan 7	-28.99	-24.02	-26.92	-32.72	239.10	122.10	248.55

Table 9

Effects of Reforestation Associated with Project Plans on Terrestrial Wildlife Habitats Under Scenario B1 or B2[1], Yazoo Backwater Project

	Net Change in Average Annual Habitat Units (AAHU)						
Project Plan[2]	Barred Owl	Gray Squirrel	Carolina Chickadee	Pileated Woodpecker	Wood Duck	Mink	Total
			Lower Ponding Area				
Plan 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 2	21,365.70	29,762.70	29,109.60	16,794.00	0.00	0.00	97,032.00
Plan 2A	13,980.45	19,474.95	19,047.60	10,989.00	0.00	0.00	63,492.00
Plan 2B	4,534.20	6,316.20	6,177.60	3,564.00	0.00	0.00	20,592.00
Plan 2C	19,648.20	27,370.20	26,769.60	15,444.00	0.00	0.00	89,232.00
Plan 3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 4	6,389.10	8,900.10	8,704.80	5,022.00	0.00	0.00	29,016.00
Plan 5	9,549.30	13,302.30	13,010.40	7,506.00	0.00	0.00	43,368.00
Plan 6	13,980.45	19,474.95	19,047.60	10,989.00	0.00	0.00	63,492.00
Plan 7	21,365.70	29,762.70	29,109.60	16,794.00	0.00	0.00	97,032.00
			Upper Ponding Area				
Plan 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 2	21,365.70	29,762.70	29,109.60	16,794.00	0.00	0.00	97,032.00
Plan 2A	13,980.45	19,474.95	19,047.60	10,989.00	0.00	0.00	63,492.00
Plan 2B	4,534.20	6,316.20	6,177.60	3,564.00	0.00	0.00	20,592.00
Plan 2C	19,648.20	27,370.20	26,769.60	15,444.00	0.00	0.00	89,232.00
Plan 3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 4	6,389.10	8,900.10	8,704.80	5,022.00	0.00	0.00	29,016.00
Plan 5	9,549.30	13,302.30	13,010.40	7,506.00	0.00	0.00	43,368.00
Plan 6	13,980.45	19,474.95	19,047.60	10,989.00	0.00	0.00	63,492.00
Plan 7	21,365.70	29,762.70	29,109.60	16,794.00	0.00	0.00	97,032.00

Continued.

Table 9 concluded.

Project Plan[2]	Net Change in Average Annual Habitat Units (AAHU)						
	Barred Owl	Gray Squirrel	Carolina Chickadee	Pileated Woodpecker	Wood Duck	Mink	Total
			Lower and Upper Ponding Areas Combined				
Plan 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 2	42,731.40	59,525.40	58,219.20	33,588.00	0.00	0.00	194,064.00
Plan 2A	27,960.90	38,949.90	38,095.20	21,978.00	0.00	0.00	126,984.00
Plan 2B	9,068.40	12,632.40	12,355.20	7,128.00	0.00	0.00	41,184.00
Plan 2C	39,296.40	54,740.40	53,539.20	30,888.00	0.00	0.00	178,464.00
Plan 3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 4	12,778.20	17,800.20	17,409.60	10,044.00	0.00	0.00	58,032.00
Plan 5	19,098.60	26,604.60	26,020.80	15,012.00	0.00	0.00	86,736.00
Plan 6	27,960.90	38,949.90	38,095.20	21,978.00	0.00	0.00	126,984.00
Plan 7	42,731.40	59,525.40	58,219.20	33,588.00	0.00	0.00	194,064.00

[1] Planned reforestation acres under the two scenarios (B1 and B2) were identical.
[2] Acres to be reforested were arbitrarily divided equally between ponding areas.

Table 10

Combined Effects of Project Construction and Reforestation on Terrestrial Wildlife Habitats Under Scenario B1[1], Yazoo Backwater Project

	Net Change in Average Annual Habitat Units (AAHU)						
Project Plan[2]	Barred Owl	Gray Squirrel	Carolina Chickadee	Pileated Woodpecker	Wood Duck	Mink	Total
				Lower Ponding Area			
Plan 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 2	21,365.70	29,762.70	29,109.60	16,794.00	0.00	0.00	97,032.00
Plan 2A	13,980.45	19,474.95	19,047.60	10,989.00	0.00	0.00	63,492.00
Plan 2B	4,534.20	6,316.20	6,177.60	3,564.00	-2,575.66	-529.67	17,486.67
Plan 2C	19,648.20	27,370.20	26,769.60	15,444.00	0.00	0.00	89,232.00
Plan 3	-28.99	-24.02	-26.92	-32.72	0.00	0.00	-112.65
Plan 4	6,360.11	8,876.08	8,677.88	4,989.28	168.90	0.00	29,072.25
Plan 5	9,520.31	13,278.28	12,983.48	7,473.28	168.90	0.00	43,424.25
Plan 6	13,951.46	19,450.93	19,020.68	10,956.28	168.90	70.93	63,619.18
Plan 7	21,336.71	29,738.68	29,082.68	16,761.28	168.90	70.93	97,159.18
				Upper Ponding Area			
Plan 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 2	21,365.70	29,762.70	29,109.60	16,794.00	0.00	0.00	97,032.00
Plan 2A	13,980.45	19,474.95	19,047.60	10,989.00	0.00	0.00	63,492.00
Plan 2B	4,534.20	6,316.20	6,177.60	3,564.00	-545.90	-249.39	19,796.71
Plan 2C	19,648.20	27,370.20	26,769.60	15,444.00	0.00	0.00	89,232.00
Plan 3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 4	6,389.10	8,900.10	8,704.80	5,022.00	70.20	0.00	29,086.20
Plan 5	9,549.30	13,302.30	13,010.40	7,506.00	70.20	0.00	43,438.20
Plan 6	13,980.45	19,474.95	19,047.60	10,989.00	70.20	51.17	63,613.37
Plan 7	21,365.70	29,762.70	29,109.60	16,794.00	70.20	51.17	97,153.37

Continued.

Table 10 concluded.

Project Plan[2]	Net Change in Average Annual Habitat Units (AAHU) Barred Owl	Gray Squirrel	Carolina Chickadee	Pileated Woodpecker	Wood Duck	Mink	Total
	Lower and Upper Ponding Areas Combined						
Plan 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plan 2	42,731.40	59,525.40	58,219.20	33,588.00	0.00	0.00	194,064.00
Plan 2A	27,960.90	38,949.90	38,095.20	21,978.00	0.00	0.00	126,984.00
Plan 2B	9,068.40	12,632.40	12,355.20	7,128.00	-3,121.56	-779.06	37,283.38
Plan 2C	39,296.40	54,740.40	53,539.20	30,888.00	0.00	0.00	178,464.00
Plan 3	-28.99	-24.02	-26.92	-32.72	0.00	0.00	-112.65
Plan 4	12,749.21	17,776.18	17,382.68	10,011.28	239.10	0.00	58,158.45
Plan 5	19,069.61	26,580.58	25,993.88	14,979.28	239.10	0.00	86,862.45
Plan 6	27,931.91	38,925.88	38,068.28	21,945.28	239.10	122.10	127,232.55
Plan 7	42,702.41	59,501.38	58,192.28	33,555.28	239.10	122.10	194,312.55

[1] Scenario B2 was nearly identical.
[2] Acres to be reforested were arbitrarily divided equally between areas.

Table 11

Estimated Benefits Of Establishment Of Bottomland Hardwood Forest
Under Various Management Plans

Management Plan[1]	Increase in Average Annual Habitat Units (AAHU) per 100 Acres						
	Barred Owl	**Gray Squirrel**	**Carolina Chickadee**	**Pileated Woodpecker**	**Wood Duck**	**Mink**	**Total**
	Natural Succession						
MP 1	34.35	25.95	46.80	27.00	0.00	0.00	134.10
MP 2	34.35	25.95	46.80	27.00	62.70	44.55	241.35
MP 3	34.35	25.95	46.80	27.00	62.70	55.65	252.45
	Reforestation with Hard-Mast Trees						
MP 4	34.35	47.85	46.80	27.00	0.00	0.00	156.00
MP 5	34.35	47.85	46.80	27.00	62.70	44.55	263.25
MP 6	34.35	47.85	46.80	27.00	62.70	55.65	274.35

[1] Restrictions (see text for details):

MP 1 and MP 4 assume that the mitigation site floods less than 25% of the year, and is not located within 328 ft of a lake or stream that contains water more than 25% of the year. Thus, habitat benefits accrue only to the generalist species.

MP 2 and MP 5 apply to sites entirely within 328 ft of a lake or stream that contains water for 6 months per year, or the site is forested wetland flooded for 6 months per year. The site is shallowly flooded during the March-to-May wood duck brood-rearing period, abundant over-water brood cover is present, and well-maintained nest boxes are provided. If adjacent to a stream or lake, the streambank or shoreline is well vegetated providing ample cover for foraging mink.

MP 3 and MP 6 apply to sites entirely within 328 ft of a lake or stream that contains surface water >9 months per year, or the site is forested wetland shallowly flooded >9 months per year. Other requirements given under MP 2 and MP 5 apply.

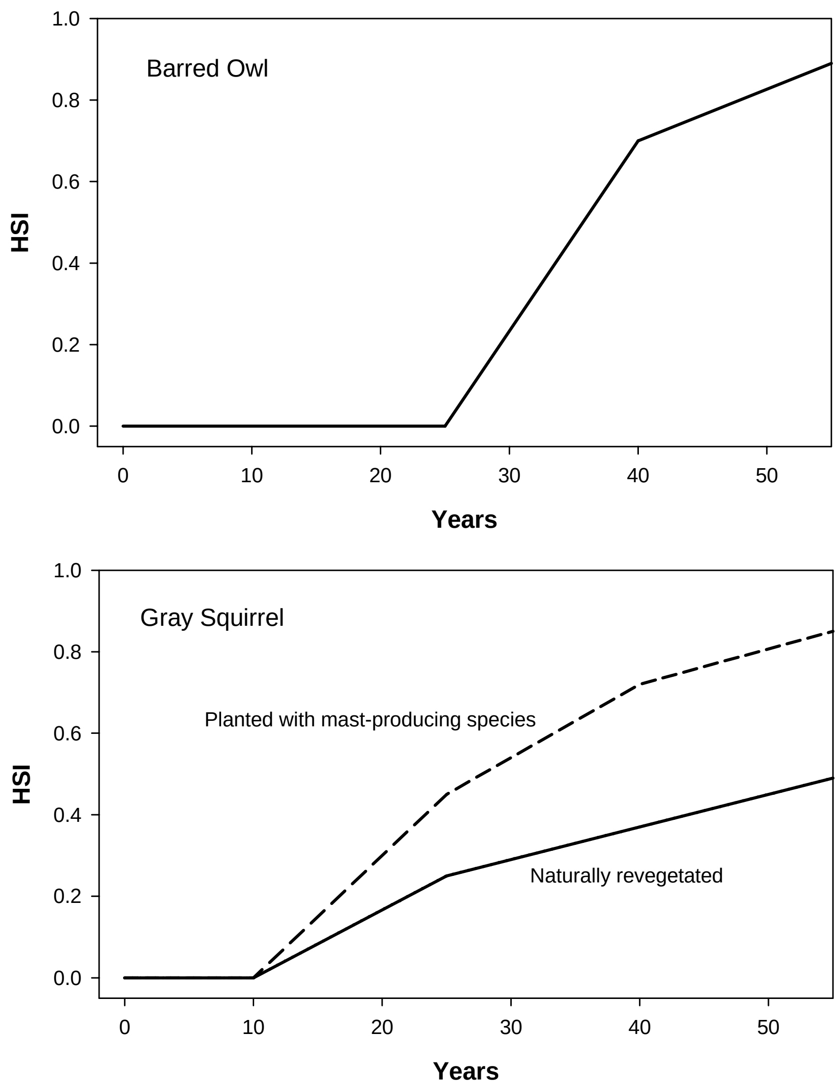

Figure 1. Models of habitat development for barred owls (upper) and gray squirrels (lower) following reforestation of existing cleared land (Wakeley and Marchi 1991).

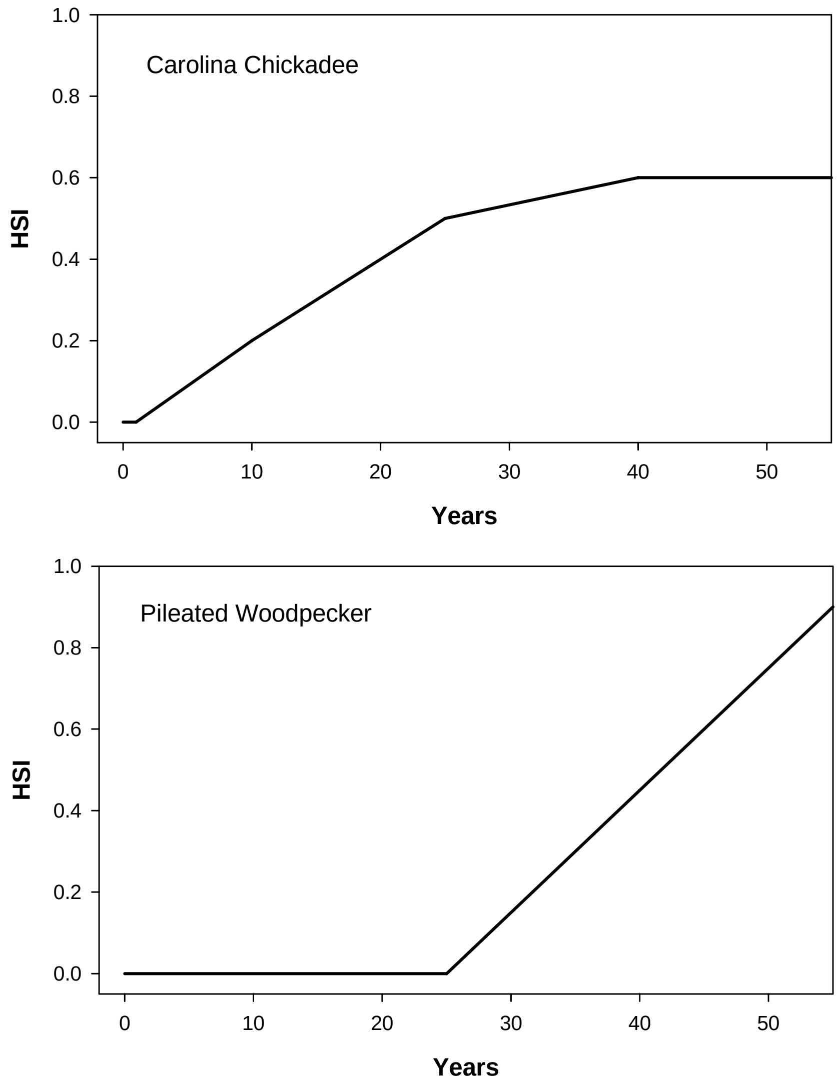

Figure 2. Models of habitat development for Carolina chickadees (upper) and pileated woodpeckers (lower) following reforestation of existing cleared land (Wakeley and Marchi 1991).

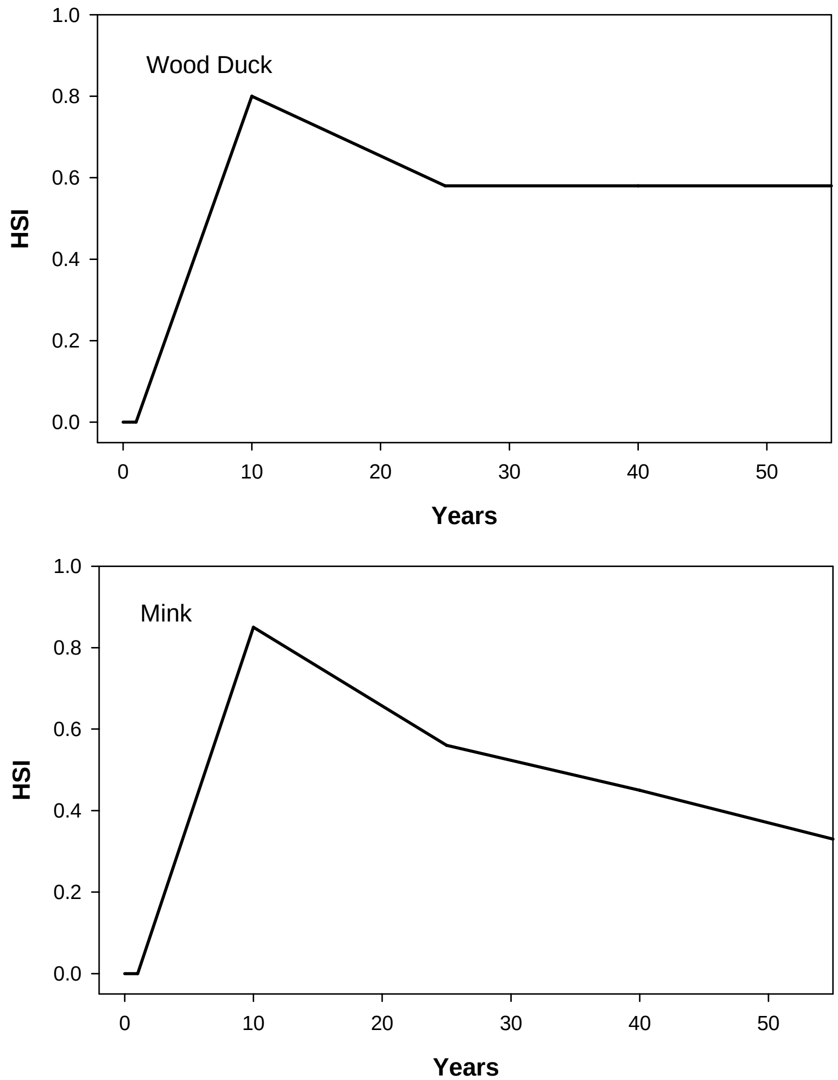

Figure 3. Models of habitat development for wood ducks (upper) and mink (lower) following reforestation of existing cleared land (Wakeley and Marchi 1991).