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Mitch, Doug

Enclosed you will find the final draft of the HEP report.

Please review and make any corrections in red ink. Please return your comments to me

ASAP or just call me if you have no significant changes to make. As soon as all comments have been received from the team,

they will be incorporated and the final report will be completed at last. I look forward to hearing from you.

Don

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Technical Report

An Application of the Habitat
Evaluation Procedures
on the
Columbia Dam Segment
of the Duck River Project

by

Don Allsbrooks
Mitch King
Doug Pelren
Ed Penrod
Tom Sheddan
Doug Winford

April 28, 1983

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INTRODUCTION

The Tennessee Valley Authority's (TVA) Columbia Dam segment of the Duck River project is located in Maury County, Tennessee, approximately 40 miles south of Nashville. The dam is being constructed on the Duck River at river mile 136.9 just upstream from the city of Columbia. When completed, the maximum normal pool will affect normal river patterns upstream to approximate river mile 191.0 and inundate 14,753 acres of terrestrial habitat and 54 miles of stream. The primary purposes of the Duck River project are water supply, flood control, recreation, higher and better land use, and enhanced employment. In addition to the lake area, TVA intends to purchase 13,735 acres of adjacent properties, bringing the total project area to 28,488 acres.¹ Project construction and land acquisition began in 1970, with an anticipated completion date of 1985.²

In November 1977, TVA applied for a Department of the Army, Corps of Engineers, permit under Section 404 of the Clean Water Act to deposit fill material within the Duck River during dam construction. In connection with the Section 404 permit for Columbia Dam, issued by the Corps of Engineers on August 5, 1981, TVA will apply Habitat Evaluation Procedures (HEP), in cooperation with the Tennessee Wildlife

1. Acreage figures utilized within this report were developed using aerial photography and available project data. The figures may deviate from other acreage calculations related to Columbia Dam due to inherent errors in photography and habitat mapping. However, these deviations were expected, and it is the opinion of the evaluation team that correction will not significantly alter the results of the Habitat Evaluation Procedures.

2. This completion date was provided by TVA at the beginning of this analysis. Since that time TVA has determined that this date may be unrealistic, and a 1986 completion date may be more accurate. However, such a change would not be expected to significantly alter the outcome of the analysis.

Resources Agency (TWRA) and the U.S. Fish and Wildlife Service (FWS). The procedures are a habitat-based methodology for quantifying project effects on fish and wildlife resources. The results of the HEP application will be presented to the Corps for review and comment and will be factored into any decision about fish- and wildlife-related mitigation.

This report represents the results of the HEP as they were applied to Columbia Dam by an evaluation team consisting of six biologists from TVA, TWRA, and the FWS. The purposes of this report are to explain the HEP application and present and discuss its results. The report should not be interpreted as the official position of any agency represented on the evaluation team. Instead, it is a data source to be used by these agencies in developing their positions regarding fish- and wildlife-related measures currently planned for Columbia Dam.

HEP APPLICATION

This report does not attempt to explain the HEP, only its application to Columbia Dam. For a full understanding of the HEP the reader is directed to FWS document number ESM 102, entitled "Habitat Evaluation Procedures," which is available from the Division of Ecological Services, U.S. Fish and Wildlife Service, Department of the Interior, Washington, D.C. 20240.

For clarity, this discussion is presented in five parts. The first part addresses the condition of the habitat in the area before Columbia Dam was proposed (baseline condition). The second presents future projections of habitat quality and quantity, with and without Columbia Dam. The third part is a comparison of the future conditions with and without the project and discusses the procedure used to compare habitat values between evaluation

species. Parts four and five discuss the net effects expected from the management activities aimed at increasing the quality of wildlife habitat on project areas.

Baseline Conditions

The initial step in applying the HEP is to quantify the value of the habitat at the baseline condition. This effort began in February 1982 with an interagency meeting that identified the evaluation team and the study area. Table 1 identifies the evaluation team members, their agency affiliation, expertise, and level of HEP training. The study area was identified by the team as the entire proposed TVA purchase area (28,488 acres). Once the study area was delineated, a vegetative cover-type map was developed. This task was performed almost exclusively by the TVA team members and their supporting personnel at TVA. To obtain accurate baseline maps, 1971 aerial photography was used. The result was a high quality set of 1:24,000, color-coded overlays identifying seven cover types. Table 2 presents these cover types and a description of each. The cover-type maps were used to determine the acreage of the various cover types, to measure distances between cover types for the purpose of interspersion calculations, and to aid in the selection of field sampling sites.

Sample sites were selected using grid overlays and a random numbers table. Approximately 15 sample sites were selected in each cover type and numbered in order of selection. The team agreed that, where practical, sites would be visited in order of selection until an adequate sample size was achieved.

The selection of evaluation species and the development of Habitat Suitability Index (HSI) models for these species were also tasks performed

by the team prior to the field investigation. A total of 18 species was selected by the team as evaluation species. In developing the HSI models the team agreed to utilize, where possible, standard models developed by the FWS Western Energy and Land Use Team. Most of the models had been used previously in HEP applications on the Big Sandy River and Dan River water development projects in Texas and North Carolina, respectively. Initially, no specific modifications were identified for these models. However, after performing field evaluations it was determined that some alterations would be necessary to yield accurate results in this study area. Table 3 identifies the evaluation species, the source of the HSI models, and modifications to those models if such modifications were necessary.

During April and May of 1982, the evaluation team performed the field analysis, visiting between 5 and 10 sample sites in each cover type. At each terrestrial sample site, particular measurements of vegetative cover and proximity to other cover types were taken. An established procedure was followed for measuring specific variables. This procedure involved identifying the sampling point and marking a 0.1-acre circular plot, five 1-meter-square plots, and a 74-foot-long 2-meter-wide transect at each site. Table 4 identifies the parameters measured and the cover types and type of plot in which they were measured.

The analysis of aquatic fishery habitat was done somewhat differently since all of the data needed to complete the HSI models were available from previous aquatic data surveys performed by TWRA, TVA, or U.S. Geological Survey (USGS). However, some generalized field observations concerning lake conditions were made at terrestrial sample sites, such as ground elevation, soil conditions, and anticipated future cover. Table 5 identifies the parameters used in the aquatic analysis and the source from which they were obtained.

After the collection of the field data, the FWS representatives of the team were responsible for analyzing these data to determine the HSI for each evaluation species. The field data, along with acreage and interspersed figures derived from the TVA mapping effort, were then applied to the appropriate models. The result was a display of average HSI, available acreage, and available Habitat Units (HU) for each evaluation species at the baseline year of 1971 (table 6).

Future Conditions

From the baseline conditions, two future conditions were projected by the evaluation team. The first condition assumes Columbia Dam had never been considered (future without the dam), and the second assumes the project is carried through to completion (future with the dam). These projections were based on numerous assumptions of future events. In the terrestrial analysis, these assumptions related primarily to changes in the vegetative composition of the cover types over time, and are based upon the experience and expertise of the team members. However, several assumptions dealt with acreage changes as a result of specific project actions or trends in populations, and were based on information supplied by TVA, TWRA, and/or the judgment of the team. In the aquatic analysis, many of the future with project conditions were provided by TVA water quality personnel, while nonwater quality parameters were projected by the team members. The future without conditions were based on the judgment of the team. Tables 7 and 8 display the assumptions used for projecting the future conditions without and with the project, respectively.

A period of 64 years was used for this analysis, beginning in 1971 and ending 50 years after the proposed dam closure (2035). Several Target

Years were identified during this period for application of analysis.

Target Year selection was based on expected events such as dam closure and changes in vegetation or water quality. Table 9 presents the Target Years identified and the reason for their selection.

At each Target Year the evaluation team analyzed each of the previously discussed assumptions to determine what impact that assumption would have on each parameter in the HSI models. As in the baseline calculations, these new parameter values were applied to each species along with acreage projections to arrive at HSI, acreage, and HU figures at each Target Year.

In the terrestrial analysis, specific modification to the procedure as presented in the baseline condition was necessary under both future conditions because of assumptions made by the team. In the future without the dam condition a new cover type labeled development lands had to be created to account for lands lost to residential development (table 7, Assumption 2). The future with the dam was more difficult to analyze, with several assumptions causing modification. Basically, the study area was segmentalized because specific zones were identified where impacts to the HSI calculations would be significantly different. These zones included the Sowell/Tugas Wildlife Management Area (WMA),³ recreation areas, the dam site, and Other Areas⁴ (table 8, Assumptions 4, 7, 8, and 9). Two of these segments, recreation areas and the dam site, were determined to have no significant value to wildlife (table 8, Assumptions 4 and 8), and were not included in the future analysis. The remaining segments all possessed some wildlife value and were included in the analysis. Tables 10 and 11 display

3. TVA intends to make 1,753 acres of project lands available to TWRA for management in the vicinity of Sowell and Tugas Bends.

4. Other areas include approximately 9,282 acres of project lands that have no specified use.

HSI, Available Acres, and HU figures for both fish and wildlife species for the future without condition, while tables 12, 13, and 14 display similar figures for segmented areas of value in the future with the project condition.

Utilizing the figures displayed in tables 10-14 it was then possible to develop an average annual HU available figure for each species in the two future conditions. This is done using a process called annualization, which applies the following formula to the HSI and Available Acres figure for specific target years:

$$\text{Cumulative HUs} = (T2 - T1) \frac{A1H1 + A2H2}{3} + \frac{A2H1 + A1H2}{6}$$

where

T1 = first Target Year of time interval

T2 = last Target Year of time interval

A1 = area of available habitat at beginning of time interval

A2 = area of available habitat at end of time interval

H1 = HSI at beginning of time interval

H2 = HSI at end of time interval

3 and 6 = constants derived from integration of HSI × Area for the interval between any two target years

This formula was applied to each time interval between Target Years, and the results were summed and divided by the total period of analysis. Table 15 displays the results of this process as well as a comparison of the future conditions. This comparison is the net habitat change which can be expected from Columbia Dam on each evaluation species.

Determination of Columbia Dam Effects

Table 15 displays the net habitat change (in average annual HUs lost or gained) Columbia Dam is expected to have on each evaluation species.

While this information is helpful in accounting for habitat changes to each species, basic unquantified differences between species make it impossible to simply combine the figures to display a total net change. These differences relate to the economic and ecological importance of an evaluation species.

In an effort to obtain this single figure of net habitat change, the evaluation team used a process of ranking the evaluation species among themselves, to get a Relative Value Index (RVI) for each species which can be applied to the net HU impact for that species to yield an equivalent HU impact. This equivalent HU figure can then be combined for all species to determine the net habitat change from the dam. This process involved ranking each evaluation species with the other using economic value, recreational use, aesthetic value, and ecosystem importance as the criteria for ranking. Table 16 shows the resultant RVI for each evaluation species, as well as the application of that figure to previously developed net HU impact figures. The result is an equivalent net HU impact figure for each species which can now be summed to arrive at a single net impact figure as has been done in table 16. According to this analysis Columbia Dam will result in the annual loss of approximately 5,031 equivalent HUs of fish and wildlife habitat.

Management of the Sowell/Tugas Area for Wildlife

As presented in the previous discussion on future conditions, and in table 8, assumption 7, TVA intends to offer a total of approximately 1,753 acres in the vicinity of Sowell and Tugus Bends to TWRA for the purpose of wildlife management. The TWRA team members presented a general management plan that would be implemented on the area. This plan is aimed primarily at providing suitable nesting, feeding, and resting habitat for

Canada geese and includes measures such as agricultural leasing and placement of floating nesting structures. Habitat changes related to other species, either positive or negative, are incidental to this species-specific type of management.

Because this proposal is considered an integral part of the project, this management plan was incorporated into the future with the project condition as it was presented previously and in tables 12-15. In an effort to quantify the net habitat change attributable to the act of management it was necessary to determine the habitat value of the Sowell/Tugas Area without management by TWRA. Table 17 shows the HUs available assuming the Sowell/Tugas Area received the same treatment as the Other Areas within the project boundary. For comparison, this table also displays similar HU figures for management of the area, and net habitat change as a result of management.

The result is that management of the Sowell/Tugas WMA yields an annual increase of 1,271 equivalent HUs. Therefore, by applying this net gain figure to the net loss figure developed previously (5,031 equivalent HUs), it can be assumed that approximately four (5,031/1,271) additional areas the same size as Sowell/Tugas WMA (1,753 acres), or approximately 7,000 acres, managed in a manner similar to that area, would offset project induced wildlife habitat losses.

Management of the Other Areas for Wildlife

In an effort to offset the net habitat change expected from the dam, TVA has developed a wildlife management plan and proposes to implement that plan on all or part of the 9,282 acres of land known as Other Areas. The TVA plan differs from the one proposed by TWRA in that it is not aimed at a particular species. Management practices revolve around

selective timber cutting to improve the quality of the upland hardwoods, maintaining and improving the quality of roughly 20 percent of the abandoned agriculture fields, strict wildlife-oriented agricultural leases on approximately 2,300 acres of existing agricultural fields, and placement of floating nesting structures for Canada geese.

Utilizing the TVA management plan, the evaluation team projected each of the parameter values and applied these new values to the models for each species. As a result of this effort it was found that if the management plan were applied to the entire 9,282 acres, a net benefit of 8,210 equivalent HUs can be expected (table 18). This calculates to an average of .88 equivalent HUs gained for each acre of managed land. Therefore, to offset the expected dam induced loss of 5,031 equivalent HUs, this management plan should be implemented and strictly adhered to on approximately 5,689 acres ($5,031/.88$) in addition to the Sowell/Tugas WMA.

SUMMARY

According to this HEP application, completion of Columbia Dam will result in the net loss of approximately 5,031 equivalent HUs annually. This loss figure covers all aspects of the project within the project boundaries including the dedication and management of the Sowell/Tugas WMA. However, because the HEP relates only to habitat quality and quantity, no benefit is attributed to activities that do not increase the quality or quantity of fish or wildlife habitat. Therefore, several actions proposed by TVA such as fish rearing ponds, hunter access, hatchery facilities, bank and handicap fishing facilities, wildlife observation tower, and boat ramps for year-round access are not considered by the HEP.

In an effort to determine what additional measures could be taken to offset the net loss figure, the team identified two basic approaches. The first was to make additional lands available to TWRA for management in a manner similar to that proposed for the Sowell/Tugas WMAa. The second approach is for TVA and TWRA to assume joint responsibility for wildlife management under a plan aimed more toward upland-oriented wildlife on these additional areas rather than the species-specific management proposed on the Sowell/Tugas WMA. Both of these compensation packages would utilize a portion of the 9,282 acres of Other Areas within the purchase boundaries of the project.

The HEP application revealed that if TWRA were given the responsibility of managing additional areas in a manner similar to that proposed for the Sowell/Tugas Area, an additional 7,000 acres would be necessary to offset project-induced habitat losses. The gains expected from the management will be largely gains in Canada goose habitat, with minor gains in openland-oriented wildlife habitat, and losses in forest-oriented habitat.

The alternative approach, TVA management, would require approximately 5,689 acres of the Other Areas within the project boundary to be dedicated and managed according to the previously presented management plan. With this management plan, gains from management occur in 10 of the 12 terrestrial evaluation species, with no species showing a loss as a result of the management.

To summarize, the HEP have been used to identify what measures would be necessary to offset fish and wildlife habitat losses expected to result from the completion of Columbia Dam. This can be achieved by reassigning a major portion of the Other Areas to wildlife management.

EVALUATION TEAM SIGNATURES

This HEP application was performed by the evaluation team with the realization that the procedures have certain deficiencies. HSI models were developed for Nation-wide application and required significant changes to make them more applicable to this region. In addition, species selection is an important part of the HEP application, which can significantly bias the outcome. However, it was jointly agreed that the HEP are the best methodology for quantification of fish and wildlife habitat currently available to the evaluation team. In addition, the evaluation team will submit a critique of the HEP to the Western Energy and Land Use Team of the U.S. Fish and Wildlife Service. Copies of this critique are available from the evaluation team members upon request.

Don Allsbrooks	Wildlife Biologist	TVA

Mitch King	Fish and Wildlife Biologist	FWS

Doug Pelren	Fishery Biologist	TWRA

Ed Penrod	Wildlife Biologist	TWRA

Tom Sheddan	Fishery Biologist	TVA

Doug Winford	Fish and Wildlife Biologist	FWS

TABLES

Table 1. A listing of the members of the Evaluation Team.

Name	Agency	Title	HEP Training
Don Allsbrooks	TVA	Wildlife Biologist	Yes
Mitch King	FWS	Fish & Wildlife Biologist	Yes
Doug Pelren	TWRA	Fishery Biologist	No
Ed Penrod	TWRA	Wildlife Biologist	No
Tom Sheddan	TVA	Fishery Biologist	No
Doug Winford	FWS	Fish & Wildlife Biologist	Yes

Table 2. Vegetative cover types identified from aerial photography of the project area.

Cover Type	Existing Acres (1971)*	General Description
Upland Hardwoods	6,800	Primarily oak-hickory forest type; less prominent species include beech, sweetgum, ironwood, and hackberry; eastern red cedars are abundant in some areas; average DBH† of overstory species is 12 inches; midstory vegetation and ground cover are moderate.
Riparian Hardwoods	2,640	Typical forested riparian zone; dominant species include boxelder, sycamore, hackberry, and numerous species of oak and hickory; midstory cover is moderate; ground cover is heavy; average DBH of overstory is 15 inches.
Cedars	671	Eastern red cedar is dominant tree species; midstory vegetation is heavy; ground cover is moderate.
Abandoned Agriculture	1,886	Cropland and pasture areas abandoned for several years; shrub growth and ground cover are heavy.
Pasture	7,941	Poorly managed, heavily grazed; weed species abundant; primary grass species is fescue.
Cropland	6,883	Primary crops include soybeans and corn; fields are relatively small with numerous overgrown fence and hedge rows.
Riverine	1,667	Primarily within the Duck River; current is slow with rock/sand bottom; bank and shallow areas are usually heavily vegetated with numerous downed logs, shrubs and root outcroppings; virtually all of adjacent shorelines are forested.

*1971 acreage figures were used to determine conditions of the area prior to any action by TVA (baseline condition), and were developed by the Evaluation Team through the use of aerial photography.

†Diameter at breast height.

Table 3. A list of the Evaluation Species, model sources, and an explanation of model changes.

Evaluation Species	Model Source	Model Changes
Bobwhite Quail	WELUT*	None
Canada Goose	TVA	None
Channel Catfish	WELUT	Minor modifications were necessary to regionalize the models
Eastern Cottontail	WELUT	Modified function for winter food to decrease value of grain
Gray Squirrel	WELUT	None
Green Heron	WELUT	None
Largemouth Bass	WELUT	Minor modifications were necessary to regionalize the models
Mink	WELUT	None
Mourning Dove	WELUT	None
Muskrat	WELUT	None
Northern Hogsucker	WELUT	Minor modifications were necessary to regionalize the models
Raccoon	WELUT	None
Red-tailed Hawk	WELUT	None
Smallmouth Bass	WELUT	Developed functions for all life requisites (functions were lacking in WELUT model)
Turkey	WELUT	None
White Crappie	WELUT	Minor modifications were necessary to regionalize the models

Table 3. Continued.

Evaluation Species	Model Source	Model Changes
White-tailed Deer	WELUT	None
Wood Duck	WELUT	Altered interspersion index graph to place more emphasis on nesting acres near water

*U.S. Fish and Wildlife Service, Western Energy and Land Use Team,
2625 Redwing Road, Fort Collins, Colorado 80526.

Table 4. Display of the parameters measured for the terrestrial portion of the HEP in each habitat type.

Parameter	Cover Types*	Type of Sample Plot
% herbaceous canopy cover	UH, RH, C, AA, P, CR	meter square†
% herbaceous canopy cover green in winter months	UH, RH, C, AA, P	meter square†
% herbaceous canopy cover excluding grasses	UH, RH, C, AA, P, CR	meter square†
Average height of herbaceous canopy	UH, RH, C, AA, P	meter square†
Availability of weed, grass or grain seed	UH, RH, C, AA	meter square†
% overstory canopy closure	UH, RH, C, AA	meter square†
% overstory canopy closure of mast producing trees	UH, RH, C	meter square†
% of overstory canopy in pine	UH, RH	meter square†
Average DBH of overstory trees	UH, RH	circular†
Number of potential nest cavities	UH, RH	circular†
Number of refuge sites	UH, RH, C, AA, P	circular†
Number of trees with a DBH greater than 20 inches	UH, RH	circular†
Forest size class	UH, RH	office§
Size of continuous forest	UH, RH	office§
Distance to water	UH, RH, AA	office§
Water regime	UH, RH, AA, R	office§
Number of woody stems greater than 3 feet tall	UH, RH, C	transect¶
% shrub crown cover	UH, RH, C, AA, P	transect¶

Table 4. Continued.

Parameter	Cover Types*	Type of Sample Plot
% crown cover of fruit producing shrubs	UH, RH, C, AA	transect¶
% shrub crown cover greater than 5 feet tall	UH, RH, C, AA	transect¶
% shrub crown cover less than 5 feet tall	UH, RH, C, AA	transect¶
% of herbaceous canopy 6-24 inches tall	C, AA, P	meter square†
Distance to forest cover	C, AA, P, CR	circular‡
Availability of large lone trees within 1 mile	C, AA, P, CR	circular‡
Availability of fence rows or other shrub cover	CR	circular‡
Type of crop	CR	circular‡
Type of crop management	CR	circular‡
% emergent herbaceous canopy cover	R	transect#
% of water area covered by logs or brush	R	transect#
% of water area less than 6 feet deep	R	transect#
% of water area less than 10 inches deep	R	transect#
Water current	R	office§
Permanence of water	R	office§
Water body type	R	office§
Aquatic substrate	R	office§
Distance to forest nesting areas	R	office§

Table 4. Continued.

Parameter	Cover Types*	Type of Sample Plot
% herbaceous canopy within 25 meters of water areas	R	transect#
% of ground covered with logs brush or woody vegetation	R	transect#

*UH-upland hardwoods; RH-riparian hardwoods; C-cedars; AA-abandoned agriculture; P-pasture; CR-cropland; R-riverine

†The results of 5 square meter areas at each sample site were averaged.

‡This plot included a circular 0.1-acre area with a radius of 37.25 feet.

§Office measurements were taken using a scaled cover-type map or derived from other measurements taken in the field.

¶The transect sample plot involved an area 74.0 feet long and 6.5 feet wide extending across the 0.1-acre circular plot. Woody stem measurements involved walking the entire transect, while shrub canopy measurements used sub-areas in this transect 2 meters wide on each side.

#Riverine transects included an average of three 2-meter-wide transects extending across the water body and on shore for 25 meters. Measurements in the river were estimated from shore in most instances; however, depths were checked from a boat on occasion. Shoreward transects were broken into three 2-meter-square plots each for measurement.

Table 5. Display of the variables measured for the aquatic portion of the HEP.

Variable	Cover Types*	Data Sources†
Average water temperature during spawning and incubation	R, L	USGS, TVA
Average water temperature during growing season	R, L	USGS, TVA
Average water temperature during midsummer	R, L	USGS, TVA
Maximum average midsummer water temperature	R, L	USGS, TVA
Range in water temperature during midsummer	R, L	USGS, TVA
Minimum dissolve oxygen during spawning	R, L	USGS, TVA
Minimum dissolve oxygen during midsummer	R, L	USGS, TVA†
pH range during the year	R, L	USGS, TVA†
pH range during the growing season	R, L	USGS, TVA†
Maximum monthly average turbidity during the growing season	R, L	USGS, TVA
Monthly average total dissolved solids during growing season	L	TVA
Average dissolved oxygen below thermocline during summer at reservoir age 5 years and 20 years	L	TVA
Depth of epilimnion during summer at reservoir age of 5 years and 20 years	L	TVA
Dominate substrate type in riffles	R	TWRA, TVA, Field observation
Average depth of riffles during summer flow	R	TWRA, TVA, Field observation

Table 5. Continued.

Variable	Cover Types*	Data Sources†
% pools during summer flow	R	TWRA, TVA, field observation
Average depth of pools during spawning	R	TWRA, TVA
Average depth of pools during summer	R	TWRA, TVA
Stream gradient	R	TVA
Average stream width during summer flow	R	TVA, TWRA
Stream's average annual discharge	R	USGS
Pool-riffle ratio	R	TVA, TWRA
Average 5-day water level fluctuation during spawning	R, L	TVA, USGS, Team
Average water level fluctuation during growing season	R, L	TVA, USGS
% cover during midsummer	R, L	Field observation
% cover during spawning	R, L	Field observation
substrate composition	R, L	TVA, TWRA, field observation
Average current velocity at .6 depth during summer flow	R	USGS, Team
Maximum current velocity at .2 depth during spawning	R	USGS, Team

*River (R), Lake (L)

†Riverine data were obtained by field observations or from previous fieldwork by TVA, USGS, or TWRA. Data concerning the reservoir were projected by TVA or the team.

Table 6. A display of baseline data including HSI, Available Acreage and HU figures for each evaluation species.

Evaluation Species	HSI	Available* Acres	HUs†
Bobwhite Quail	.35	18,880	6,535
Canada Goose	.00	0	0
Channel Catfish	.61	1,667	1,013
Eastern Cottontail	.39	17,381	6,756
Gray Squirrel	.71	9,440	6,674
Green Heron	.36	1,667	598
Largemouth Bass	.63	1,667	1,057
Mink	.25	1,667	417
Mourning Dove	.51	17,381	8,787
Muskrat	.40	1,667	667
Northern Hogsucker	.58	1,667	962
Raccoon	.60	11,362	6,740
Red-tailed Hawk	.54	26,821	14,488
Smallmouth Bass	.42	1,667	697
Turkey	.56	26,821	15,075
White Crappie	.58	1,667	964
White-tailed Deer	.73	26,821	19,504
Wood Duck	.71	11,107	7,908

*Available acres includes the sum of the acreage of all cover types that provide at least one life requisite for the evaluation species.

†HSI × Available Acres.

Table 7. Assumptions used in the HEP analysis of the future without Columbia Dam.

Assumption Number	Assumption
1	The existing quality (HSI) of the cover types will not change throughout the period of analysis. No data exist that identify any potential action which would justify changes in crop production or crop and timber management.
2	In all cover types, except riverine and riparian hardwoods, there will be an acreage loss to residential and commercial development of 0.025 percent annually. This will allow for a slow to moderate rate of development in the vicinity of Columbia and Interstate 65.
3	The period of analysis will begin at 1971 and run until 2035, a 64-year span. This period is necessary to compare this future condition and the future with the project condition (table 8, Assumption 1).
4	Substantial habitat for the Canada Goose does not exist in the project area. Canada Goose utilization of the area is extremely limited during migration periods.
5	Within the study area tributaries to the Duck River do not provide any significant habitat for the evaluation species.
6	Under the future without project analysis, changes that would occur in the river during the next 50 years would not significantly alter the habitat suitability rating.

Table 8. Assumptions used in the HEP analysis of the future with Columbia Dam.

Assumption Number	Assumption																		
1	The period of analysis will begin at 1971 and extend for 64 years to 2035. This period will analyze all impacts of the dam, including construction and land purchase, and extend for 50 years beyond completion.																		
2	The dam will be completed and filling will begin in 1985 (based on estimation by TVA).																		
3	<p>Between 1971 and 1981, 12,877- acres mostly below the 630 contour was purchased by TVA. The following is an acreage breakdown by cover type:</p> <table style="margin-left: 40px;"> <tbody> <tr> <td>Riparian Hardwoods</td> <td>-</td> <td>1,769 acres</td> </tr> <tr> <td>Upland Hardwoods</td> <td>-</td> <td>2,379 acres</td> </tr> <tr> <td>Cedars</td> <td>-</td> <td>269 acres</td> </tr> <tr> <td>Abandoned Agriculture</td> <td>-</td> <td>967 acres</td> </tr> <tr> <td>Cropland</td> <td>-</td> <td>3,558 acres</td> </tr> <tr> <td>Pasture</td> <td>-</td> <td>3,996 acres</td> </tr> </tbody> </table> <p>A. 688 acres of Riparian Hardwoods and 912 acres of Upland Hardwoods will be preserved as standing timber areas by TVA.</p> <p>B. 1,052 acres of Cropland and 1,247 acres of Pasture will be preserved in their existing condition under agricultural leases.</p> <p>C. The remaining 8,978 acres of purchase area was converted to Abandoned Agriculture.</p>	Riparian Hardwoods	-	1,769 acres	Upland Hardwoods	-	2,379 acres	Cedars	-	269 acres	Abandoned Agriculture	-	967 acres	Cropland	-	3,558 acres	Pasture	-	3,996 acres
Riparian Hardwoods	-	1,769 acres																	
Upland Hardwoods	-	2,379 acres																	
Cedars	-	269 acres																	
Abandoned Agriculture	-	967 acres																	
Cropland	-	3,558 acres																	
Pasture	-	3,996 acres																	
4	<p>Between 1971 and 1981, 400 acres was purchased by TVA for dam site construction. This area had the following acreage configurations:</p> <table style="margin-left: 40px;"> <tbody> <tr> <td>Riparian Hardwoods</td> <td>-</td> <td>25</td> </tr> <tr> <td>Upland Hardwoods</td> <td>-</td> <td>67</td> </tr> <tr> <td>Cedars</td> <td>-</td> <td>0</td> </tr> <tr> <td>Abandoned Agriculture</td> <td>-</td> <td>50</td> </tr> <tr> <td>Pasture</td> <td>-</td> <td>195</td> </tr> <tr> <td>Cropland</td> <td>-</td> <td>63</td> </tr> </tbody> </table> <p>Once dam construction began, this acreage had no significant wildlife value (TVA and Evaluation Team estimates).</p>	Riparian Hardwoods	-	25	Upland Hardwoods	-	67	Cedars	-	0	Abandoned Agriculture	-	50	Pasture	-	195	Cropland	-	63
Riparian Hardwoods	-	25																	
Upland Hardwoods	-	67																	
Cedars	-	0																	
Abandoned Agriculture	-	50																	
Pasture	-	195																	
Cropland	-	63																	

Table 8. Continued.

Assumption Number	Assumption																					
5	Between 1981 and dam completion (1985) TVA purchases will total 28,488 acres; however, no change in cover type composition is expected on the newly purchased areas (TVA and Evaluation Team estimates).																					
6	<p>Between 1985 and 1986, dam closure will result in the inundation of 14,753 acres with the following cover type composition:</p> <table style="margin-left: 40px;"> <tr> <td>Riparian Hardwoods</td> <td style="text-align: right;">-</td> <td style="text-align: right;">688</td> </tr> <tr> <td>Upland Hardwoods</td> <td style="text-align: right;">-</td> <td style="text-align: right;">955</td> </tr> <tr> <td>Cedars</td> <td style="text-align: right;">-</td> <td style="text-align: right;">7</td> </tr> <tr> <td>Abandoned Agriculture</td> <td style="text-align: right;">-</td> <td style="text-align: right;">8,996</td> </tr> <tr> <td>Pasture</td> <td style="text-align: right;">-</td> <td style="text-align: right;">1,320</td> </tr> <tr> <td>Cropland</td> <td style="text-align: right;">-</td> <td style="text-align: right;">1,120</td> </tr> <tr> <td>Riverine</td> <td style="text-align: right;">-</td> <td style="text-align: right;">1,667</td> </tr> </table> <p>The remaining 13,734 acres of project lands will be unchanged from previous conditions. Agricultural leases are expected on 1,163 acres of Pasture and 1,144 acres of Cropland (TVA and Evaluation Team estimates).</p>	Riparian Hardwoods	-	688	Upland Hardwoods	-	955	Cedars	-	7	Abandoned Agriculture	-	8,996	Pasture	-	1,320	Cropland	-	1,120	Riverine	-	1,667
Riparian Hardwoods	-	688																				
Upland Hardwoods	-	955																				
Cedars	-	7																				
Abandoned Agriculture	-	8,996																				
Pasture	-	1,320																				
Cropland	-	1,120																				
Riverine	-	1,667																				
7	The Sowell/Tugas WMA will be created immediately after the closure of the dam and managed by TWRA under a long-term tenure agreement with TVA. As it was assessed in this analysis, the area will consist of approximately 1,753 acres of terrestrial habitat and 2,425 acres of lake habitat. The actual size of the area may change as boundary lines are finalized. Management of this area will be primarily aimed at Canada geese, with crop and pasture management being the major actions. However, other waterfowl and small game can be expected to benefit from these actions. After the HEP application this area was named the Columbia WMA; however, for the purposes of this report it will be referred to as the Sowell/Tugas WMA (based on information supplied by TVA and TWRA).																					
8	After dam closure, it is estimated that approximately 2,500 acres of the project area will be developed into recreational areas. The following is a cover type breakdown of this acreage:																					

Table 8. Continued.

Assumption Number	Assumption
	Riparian Hardwoods - 145
	Upland Hardwoods - 734
	Cedars - 66
	Abandoned Agriculture - 152
	Pasture - 658
	Cropland - 545
	Lake - 200

Due to the high level of development expected on these areas, it is assumed that this acreage will have no significant wildlife value.

- 9 The remaining 9,282 acres of terrestrial habitat was designated as Other Areas, with shoreline protection being the only specified future use. For the purposes of this analysis the only action by TVA on these areas will be acquisition. TVA identifies these areas as the Shoreline Protection Zone; however, for the purposes of this report they will be referred to as Other Areas.
- 10 Between 1986 and 1990, 2,766 acres of unleased crop and pasture lands will revert to a new cover type called Cropland/Pasture-Abandoned Agriculture (C/P-AA). Other habitat types increased slightly in quality due to natural succession (Evaluation Team estimate).
- 11 Between 1990 and 2025 natural succession will transform Abandoned Agriculture areas (603 acres) to a new cover-type called Abandoned Agriculture-Upland Hardwoods (AA-UH). The value of this new cover-type is the same as that for Upland Hardwoods at 1971. Natural succession will also increase the value of the other cover types (except leased areas) during this period (Evaluation Team estimate).
- 12 Between 2025 and 2030, the 2,766 acres of C/P-AA will revert, through natural succession to a new cover type called Cropland/Pasture-Upland Hardwoods (C/P-UH). Quality increases in other cover types (except leased areas) will also occur as a result of natural succession (Evaluation Team estimate).
- 13 Between 2030 and 2035 no identifiable change is expected in cover type quality or quantity (Evaluation Team estimate).

Table 8. Continued.

Assumption Number	Assumption
14	The winter drawdown of the reservoir would not have a significant effect on the evaluation species.
15	Usable habitat in the reservoir varies between species and life requisites. Generally, the littoral zone (defined as that portion of the shoreline to a water depth of 18 feet) was considered the only portion of the reservoir that would provide reproduction and cover habitat for the evaluation species.

Table 9. A display of the Target Years selected for this analysis and the reason for their selection.

Target Year*	Reason
1971 (T, A)	This is the baseline condition from which the analysis began.
1981 (T)	At this point approximately half of the project area had been purchased. This year is the closest to the current condition for which acreage calculations were available.
1985 (T, A)	This represents the last year before filling the lake. It is necessary to establish the condition of the area immediately before dam closure.
1986 (T)	At this point closure has occurred. This year is necessary to establish the condition of the project area after filling the lake.
1989 (A)	This year is 3 years after dam closure. It is necessary to quantify the increase in aquatic habitat as a result of impoundment.
1990 (T)	This is 5 years after TVA completed purchasing project lands. It is necessary to quantify change of Cropland and Pasture to Abandoned Agriculture (table 8, Assumption 10).
1992 (A)	This year is 6 years after dam closure. It is necessary to quantify the habitat values before the start of a gradual decline in aquatic cover.
2001 (A)	This year is 15 years after dam closure. It would quantify the habitat values after the loss of a substantial portion of the vegetative cover within the littoral zone and water quality changes resulting from impoundment and initial lake aging.
2025 (T)	This represents 40 years after TVA purchasing has completed and is necessary to quantify cover type changes from Abandoned Agriculture to Upland Hardwood forest (table 8, Assumption 11).
2030 (T)	This year is 40 years past conversion of the Cropland and Pasture cover types to Abandoned Agriculture, and is necessary to quantify

Table 9. Continued

Target Year*	Reason
2035 (T, A)	<p>this acreage's further succession to upland hardwoods (Table 8, Assumption 12).</p> <p>This year is 50 years past dam closure and represents the close of this analysis.</p>

*Target Years were different for the Terrestrial (T) and Aquatic (A) portions of the analysis and are so designated.

Table 10. Continued.

Evaluation Species	Target Years					
	1971	1981	1985	1986	1990	2035
Mourning dove						
HSI	0.51	0.51	0.51	0.51	0.51	0.51
Avail. acres	17381	16951	16783	16740	16573	14809
HU	8786.92	8569.37	8484.52	8462.69	8378.49	7486.57
Muskrat						
HSI	0.40	0.40	0.40	0.40	0.40	0.40
Avail. acres	1667	1667	1667	1667	1667	1667
HU	666.80	666.80	666.80	666.80	666.80	666.80
Raccoon						
HSI	0.60	0.60	0.60	0.60	0.60	0.60
Avail. acres	11326	11111	11027	11006	10922	10040
HU	6739.50	6618.55	6571.15	6559.10	6512.10	6015.20
Red-tailed hawk						
HSI	0.54	0.54	0.54	0.54	0.54	0.53
Avail. acres	26821	26223	25989	25929	25697	23242
HU	14487.74	14142.84	14008.03	13973.89	13839.34	12424.99
Turkey						
HSI	0.56	0.56	0.56	0.57	0.57	0.58
Avail. acres	26821	26223	25989	25929	25697	23242
HU	15074.58	14793.46	14683.02	14654.57	14545.81	13389.54
White-tailed deer						
HSI	0.73	0.73	0.73	0.73	0.73	0.74
Avail. acres	26821	26223	25986	25929	25697	23242
HU	19503.50	19123.37	18975.62	18936.62	18790.75	17231.87

Table 10. Continued.

Evaluation Species	Target Years							
	1971	1981	1985	1986	1990	2025	2030	2035
Wood duck								
HSI	0.71	0.71	0.71	0.71	0.71	0.70	0.70	0.70
Avail. acres	11107	10939	10873	10856	10791	10247	10173	10100
HU	7907.56	7770.17	7716.20	7702.29	7649.14	7204.27	7143.75	7084.05

Table 12. HSI, available acres, and HU projections for the future with Columbia Dam (Other Areas) (terrestrial species).

Evaluation Species	Target Years							
	1971	1981	1985	1986	1990	2025	2030	2035
Bobwhite quail								
HSI	0.35	1.00	1.00	0.35	1.00	0.79	0.04	0.04
Avail. acres	18880	21363	21363	6492	8119	8119	8119	8119
HU	6534.92	21363.00	21363.00	2255.40	8119.00	6384.00	324.00	324.00
Canada goose								
HSI	0.00	0.00	0.00	0.00	0.17	0.17	0.17	0.17
Avail. acres	0.00	0.00	0.00	4874	4874	4874	4874	4874
HU	0.00	0.00	0.00	0.00	844.41	844.41	844.41	844.41
Eastern cottontail								
HSI	0.39	0.66	0.66	0.38	0.72	0.48	0.34	0.34
Avail. acres	17381	19621	19621	5946	5946	5343	2577	2577
HU	6755.69	12890.14	12890.14	2278.65	4301.00	2543.65	884.05	884.05
Gray squirrel								
HSI	0.71	0.70	0.70	0.70	0.72	0.80	0.75	0.76
Avail. acres	9440	6800	6800	3336	3336	3939	6705	6705
HU	6673.58	4759.74	4759.74	2328.41	2405.30	3143.40	5016.49	5115.29
Green heron								
HSI	0.36	0.36	0.36	0.51	0.51	0.51	0.51	0.51
Avail. acres	1667	1667	1667	2334	2334	2334	2334	2334
HU	598.02	598.02	598.02	1193.47	1193.47	1193.47	1193.47	1193.47
Mink								
HSI	0.25	0.25	0.25	0.34	0.34	0.34	0.34	0.34
Avail. acres	1667	1667	1667	2031	2031	2031	2031	2031
HU	416.75	416.75	416.75	697.47	697.47	697.47	697.47	697.47

Table 12. Continued.

Evaluation Species	Target Years							
	1971	1981	1985	1986	1990	2025	2030	2035
Mourning dove								
HSI	0.51	0.46	0.46	0.50	0.47	0.71	0.51	0.51
Avail. acres	17381	19621	19621	5946	5946	5343	2577	2577
HU	8786.92	8972.80	8972.80	2979.39	2793.92	3800.72	1311.32	1311.32
Muskrat								
HSI	0.40	0.40	0.40	0.25	0.25	0.25	0.25	0.25
Avail. acres	1667	1667	1667	2031	2031	2031	2031	2031
HU	666.80	666.80	666.80	507.75	507.75	507.75	507.75	507.75
Raccoon								
HSI	0.60	0.42	0.42	0.60	0.45	0.61	0.75	0.75
Avail. acres	11326	16647	16647	3939	6705	6705	6705	6705
HU	6739.50	6958.45	6958.45	2354.20	3045.70	4057.35	5025.45	5025.45
Red-tailed hawk								
HSI	0.54	0.76	0.76	0.53	0.67	0.50	0.24	0.24
Avail. acres	26821	26421	26421	9282	9282	9282	9282	9282
HU	14487.74	20048.98	20048.98	4955.65	6258.76	4616.64	2209.12	2209.12
Turkey								
HSI	0.56	0.41	0.41	0.58	0.58	0.62	0.75	0.76
Avail. acres	26821	26421	26421	9282	9282	9282	9282	9282
HU	15074.58	10959.30	10959.30	5390.60	5390.60	5772.57	6958.69	7031.59
White-tailed deer								
HSI	0.73	0.57	0.57	0.76	0.80	1.00	1.00	1.00
Avail. acres	26821	26421	26421	9282	9282	9282	9282	9282
HU	19503.50	15085.67	15085.67	7056.95	7382.45	9282.00	9282.00	9282.00

Table 12. Continued.

Evaluation Species	Target Years							
	1971	1981	1985	1986	1990	2025	2030	2035
Wood duck								
HSI	0.71	0.67	0.67	0.45	0.45	0.46	0.49	0.49
Avail. acres	11107	8467	8467	15364	15364	15967	18733	18733
HU	7907.56	5669.97	5669.97	6879.72	6879.72	7287.57	9206.30	9206.30

Table 13. HSI, available acres, and HU projections for the future with Columbia Dam (Sowell/Tugas WMA) (terrestrial species).

Evaluation Species	Target Years							
	1971	1981	1985	1986	1990	2025	2030	2035
Bobwhite quail								
HSI	0.00	0.00	0.00	0.28	0.25	0.19	0.19	0.19
Avail. acres	0.00	0.00	0.00	1463	1608	1608	1608	1608
HU	0.00	0.00	0.00	410.00	410.00	302.40	302.40	302.40
Canada goose								
HSI	0.00	0.00	0.00	0.00	0.88	0.88	0.88	0.88
Avail. acres	0.00	0.00	0.00	2425	2425	2425	2425	2425
HU	0.00	0.00	0.00	0.00	2127.22	2127.22	2127.22	2127.22
Eastern cottontail								
HSI	0.00	0.00	0.00	0.45	0.83	0.82	0.82	0.82
Avail. acres	0.00	0.00	0.00	811	811	811	811	811
HU	0.00	0.00	0.00	364.20	674.20	663.50	663.50	663.50
Gray squirrel								
HSI	0.00	0.00	0.00	0.67	0.70	0.80	0.80	0.80
Avail. acres	0.00	0.00	0.00	942	942	942	942	942
HU	0.00	0.00	0.00	631.91	659.40	753.60	753.60	753.60
Green heron								
HSI	0.00	0.00	0.00	0.51	0.51	0.51	0.51	0.51
Avail. acres	0.00	0.00	0.00	96	96	96	96	96
HU	0.00	0.00	0.00	49.09	49.09	49.09	49.09	49.09
Mink								
HSI	0.00	0.00	0.00	0.34	0.34	0.34	0.34	0.34
Avail. acres	0.00	0.00	0.00	114	114	114	114	114
HU	0.00	0.00	0.00	39.15	39.15	39.15	39.15	39.15

Table 13. Continued.

Evaluation Species	Target Years							
	1971	1981	1985	1986	1990	2025	2030	2035
Mourning dove								
HSI	0.00	0.00	0.00	0.57	0.72	0.68	0.68	0.68
Avail. acres	0.00	0.00	0.00	811	811	811	811	811
HU	0.00	0.00	0.00	460.11	583.15	553.15	553.15	553.15
Muskrat								
HSI	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.25
Avail. acres	0.00	0.00	0.00	114	114	114	114	114
HU	0.00	0.00	0.00	28.50	28.50	28.50	28.50	28.50
Raccoon								
HSI	0.00	0.00	0.00	0.61	0.61	0.79	0.79	0.79
Avail. acres	0.00	0.00	0.00	1038	1038	1038	1038	1038
HU	0.00	0.00	0.00	636.30	636.30	824.70	824.70	824.70
Red-tailed hawk								
HSI	0.00	0.00	0.00	0.36	0.43	0.42	0.42	0.42
Avail. acres	0.00	0.00	0.00	1753	1753	1753	1753	1753
HU	0.00	0.00	0.00	631.88	748.32	730.66	730.66	730.66
Turkey								
HSI	0.00	0.00	0.00	0.70	0.76	0.89	0.89	0.89
Avail. acres	0.00	0.00	0.00	1753	1753	1753	1753	1753
HU	0.00	0.00	0.00	1220.17	1338.24	1558.04	1558.04	1558.04
White-tailed deer								
HSI	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00
Avail. acres	0.00	0.00	0.00	1753	1753	1753	1753	1753
HU	0.00	0.00	0.00	1753.00	1753.00	1753.00	1753.00	1753.00

Table 13. Continued.

Evaluation Species	Target Years							
	1971	1981	1985	1986	1990	2025	2030	2035
Wood duck								
HSI	0.00	0.00	0.00	0.51	0.51	0.51	0.51	0.51
Avail. acre	0.00	0.00	0.00	3367	3367	3367	3367	3367
HU	0.00	0.00	0.00	1731.81	1731.81	1731.81	1731.81	1731.81

Table 14. HSI, available acres, and HU projections for the future with Columbia Dam (aquatic species).

Evaluation Species	Target Years					
	1971	1985	1989	1992	2001	2035
Channel catfish						
HSI	0.61	0.61	0.58	0.58	0.53	0.47
Avail. acres	1667	1667	12600	12600	12600	12600
HU	1013.30	1013.30	7358.07	7358.07	6737.45	5980.59
Largemouth bass						
HSI	0.63	0.63	0.61	0.61	0.60	0.58
Avail. acres	1667	1667	12600	12600	12600	12600
HU	1057.11	1057.11	7712.23	7712.23	7593.24	7294.91
Northern hogsucker						
HSI	0.58	0.58	0.00	0.00	0.00	0.00
Avail. acres	1667	1667	12600	12600	12600	12600
HU	962.45	962.45	0.00	0.00	0.00	0.00
Smallmouth bass						
HSI	0.42	0.42	0.31	0.31	0.32	0.34
Avail. acres	1667	1667	12600	12600	12600	12600
HU	697.02	697.02	3892.41	3892.41	4058.13	4236.85
White crappie						
HSI	0.58	0.58	0.67	0.67	0.61	0.49
Avail. acres	1667	1667	12600	12600	12600	12600
HU	963.66	963.66	8400.95	8400.95	7725.76	6226.80

Table 15. Calculation of net change in HUs expected to result from Columbia Dam.

Evaluation Species	Average Annual HUs Available				Net Project-Induced HU Change
	Future without Project	Sowell/Tugas WMA	Other Areas	Total	
Bobwhite quail	6032	269	8204	8473	2441
Canada goose	0	1564	616	2180	2180
Channel catfish	1014	N/A	N/A	5187	4172
Eastern cottontail	6252	504	4698	5202	-1049
Gray squirrel	6331	548	3624	4172	-2160
Green heron	599	38	1058	1095	497
Largemouth bass	1055	N/A	N/A	5895	4841
Mink	417	30	632	662	245
Mourning dove	8146	432	4342	4774	-3372
Muskrat	667	22	544	566	-101
Northern hogsucker	964	N/A	N/A	307	-657
Raccoon	6380	570	4475	5046	-1334
Red-tailed hawk	13451	566	7902	8469	-4982
Smallmouth bass	698	N/A	N/A	3255	2557
Turkey	14207	1121	7276	8397	-5810
White crappie	965	N/A	N/A	5720	4755
White-tailed deer	18345	1351	10288	11639	-6705
Wood duck	7483	1331	7189	8520	1037

Table 16. Calculation of net equivalent HU change figures using relative value index (RVI).

Evaluation Species	Net Project-Induced HU Change	Relative Value Index (RVI)	Net Project-Induced Equivalent HU Change*
Bobwhite quail	2441	0.82	1993
Canada goose	2180	0.89	1939
Channel catfish	4172	0.52	2177
Eastern cottontail	-1049	0.73	-762
Gray squirrel	-2160	1.00	-2160
Green heron	497	0.64	318
Largemouth bass	4841	0.66	3174
Mink	245	0.78	192
Mourning dove	-3372	0.61	-2060
Muskrat	-101	0.68	-69
Northern hogsucker	-657	0.81	-531
Raccoon	-1334	0.82	-1091
Red-tailed hawk	-4982	0.53	-2495
Smallmouth bass	2557	0.91	2335
Turkey	-5810	0.93	-5380
White crappie	4755	0.65	3081
White-tailed deer	-6705	0.99	6661
Wood duck	1037	0.94	969
Total Project-Induced Equivalent HU Change-----			-5031

*Net Project Induced HU Change × RVI.

Table 17. Calculation of equivalent HU changes derived from management of the Sowell/Tugas WMA (terrestrial species only).

Evaluation Species	Average Annual HUs Available on Sowell/Tugas WMA			RVI	Equivalent HU Gain From Mgmt
	Without Mgmt	With Mgmt	Net Gain		
Bobwhite quail	925	269	-655	2.44	-535
Canada goose	123	1564	1441	2.66	1282
Eastern cottontail	308	504	196	2.17	142
Gray squirrel	612	548	-65	2.99	-65
Green heron	38	38	0	1.91	0
Mink	30	30	0	2.34	0
Mourning dove	313	432	119	1.83	73
Muskrat	22	22	0	2.04	0
Raccoon	600	570	-30	2.45	-24
Red-tailed hawk	715	566	-149	1.50	-75
Turkey	841	1121	280	2.77	260
White-tailed deer	1229	1351	122	2.97	121
Wood duck	1233	1331	98	2.80	92
Total Equivalent HUs Realized From Mgmt of the S/T WMA Annually-----					1272

Table 18. Calculation of equivalent HU changes derived from management of the 9,282 acres of Other Areas (terrestrial species only).

Evaluation Species	Average Annual HUs Available on Sowell/Tugas WMA			Net Gain	RVI	Equivalent HU Gain From Mgmt
	Without Mgmt	With Mgmt	With Mgmt			
Bobwhite quail	8204	9000	796	796	2.44	650
Canada goose	616	1641	1025	1025	2.66	912
Eastern cottontail	4698	6110	1412	1412	2.17	1025
Gray squirrel	3624	5858	2234	2234	2.99	2234
Green heron	1058	1058	0	0	1.91	0
Mink	632	632	0	0	2.34	0
Mourning dove	4342	4682	340	340	1.83	208
Muskrat	544	544	0	0	2.04	0
Raccoon	4475	5080	605	605	2.45	496
Red-tailed hawk	7902	8865	963	963	1.50	483
Turkey	7276	8055	779	779	2.77	722
White-tailed deer	10288	10830	542	542	2.97	538
Wood duck	7189	8195	1006	1006	2.80	942
Total Equivalent HUs Realized From Mgmt of the Other Areas Annually-----8210						