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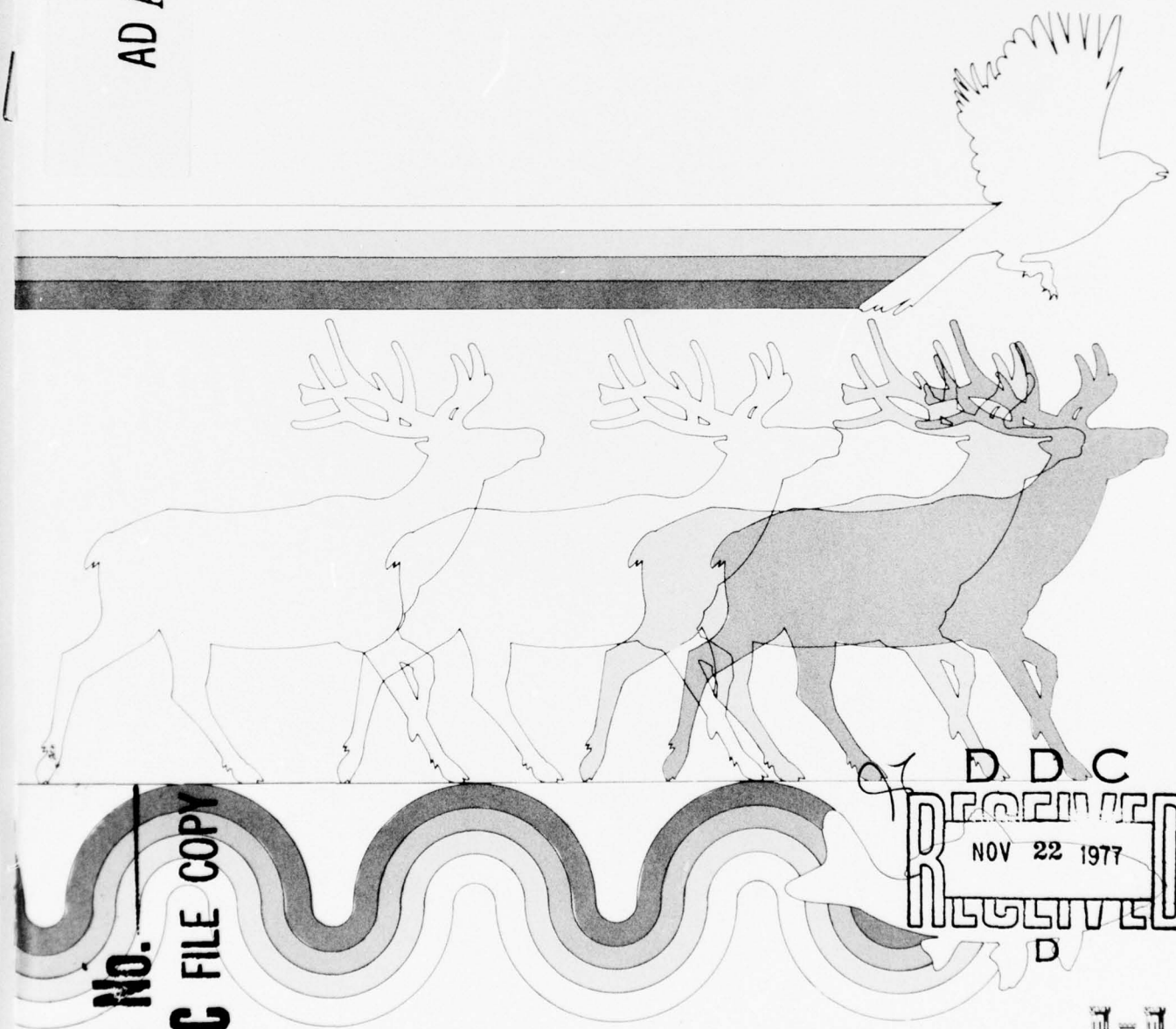
# Evaluation of Planning for Fish & Wildlife

Clark Hill
Lake Project
June 1977





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| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|---|---|
| 1. REPORT NUMBER | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE *(and Subtitle)*<br>Evaluation of Planning for Fish and Wildlife at Corps of Engineers Reservoirs - Clark Hill Lake Project | | 5. TYPE OF REPORT & PERIOD COVERED<br>Interim rept.,<br>6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br>Clark Hill | | 8. CONTRACT OR GRANT NUMBER(s)<br>DACW 73 - 74 - C - 0040 |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>Sport Fishing Institute<br>608 - 13th Street, N.W.<br>Washington, D.C. 20005 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>93 pp. |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>Office, Chief of Engineers<br>Washington, D.C. 20314 | | 12. REPORT DATE<br>June 1977<br>13. NUMBER OF PAGES<br>Sixty-four (64) |
| 14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) | | 15. SECURITY CLASS. *(of this report)*<br>15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

Copies are obtainable from National Technical Information Service, Springfield, Virginia 22151, and DDC

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Fish resources
Planning recommendations
Clark Hill Lake
Planning evaluation
Wildlife resources
Preimpoundment predictions
Postimpoundment occurences

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Clark Hill Lake received Congressional authorization in 1944 to provide power, flood control and navigation benefits. Post-authorization planning recommendations regarding the project-related fish and wildlife resources were developed by the state and federal wildlife agencies in 1945-1946. These recommendations were submitted in one of the first River Basin Studies Reports. The report was released by the FWS in 1946.

FISH AND WILDLIFE STATISTICS

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20. Abstract. (Con't)
Many deficiencies were apparent in this early attempt at interagency cooperative planning for fish and wildlife. Coordination between agencies was woefully inadequate. Consideration of several important impacts of project development on these resources were omitted in the 1946 report. An unusually large acreage was acquired by the construction agency incidental to authorized project purposes. The impacts of this acquisition plan on wildlife resources were inadequately quantified.

Major errors in estimating post-project fish and wildlife resources also occurred. Deer and turkey populations were not expected to develop after project construction due to a lack of suitable habitat. However, reforestation of much of the southeast, including the project area, dramatically altered the wildlife habitat and project lands presently support populations estimated at 3,140 deer and 735 turkey. The methods used to develop upland game and fur animal impact predictions, based on sound concepts of carrying capacity and harvestable surplus, were considered satisfactory.

Post-impoundment fishery predictions were read directly from the von Limbach Curve. No modifications of this basic relationship of surface area to monetary value were considered to reflect local conditions. Based on harvest, the Clark Hill Lake fishery is, at a minimum, five times greater than predicted.

## PREFACE

This document was prepared by staff of the Sport Fishing Institute for the U.S. Army Corps of Engineers (CE) under contract number DACW73-74-C-0040. The contract requires the compilation and comparison of pre- and post-construction data treating fish, wildlife, or both fish and wildlife (depending upon data availability) for twenty separate CE water development projects. This report presents the findings for one of the twenty individual project evaluations.

Upon completion of the full series of twenty separate studies, a final report will be prepared which will contain an analysis of the validity of the predictive procedures used in fish and wildlife planning, and will contain recommendations for improving the planning process.

This evaluation of fish and wildlife planning at the Clark Hill Lake project could not have been conducted without the cooperation and assistance of a number of agencies and their staffs. Certain planning documents and many helpful suggestions were provided by John Hester (Division of Ecological Services, U.S. Fish and Wildlife Service). Provision of project-related post-impoundment records, in some instances necessitating development of original fish and wildlife statistics, by members of the Georgia Game and Fish Division and the South Carolina Wildlife and Marine Resources Department was greatly appreciated. Jack Crockford, Terry Kile, Don Johnson and David Waller with the Georgia Division and Hampton Williams and Robert Gooding of the South Carolina Department were particularly helpful. David Brady and Tom Schulte (Savannah Dis-

trict, Army Corps of Engineers) provided much important information and always suffered our many inquiries and requests with the best of humor. Leonard Foote (Wildlife Management Institute) assisted with the original field data collection and with review of the completed manuscript.

Personnel in the environmental planning and recreation management elements of Corps agencies should review this report with a view towards improvement of Corps activities.

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SPORT FISHING INSTITUTE

PROJECT PERSONNEL

Norville Prosser (Assistant Project Leader)

Robert Martin (Project Leader)

Richard Stroud (Contractor's Representative)

## CONSULTANT'S REVIEW

Professional terrestrial wildlife consultative services were provided by the staff of the Wildlife Management Institute (WMI). Project personnel were accompanied by a WMI staff specialist during field reconnaissance and on on-site discussions. The terrestrial wildlife portion of the prepared evaluative manuscript was reviewed and evaluated by WMI. All pertinent suggestions offered by the consultant are reflected in this report.

INDIVIDUAL RESERVOIR PROJECT EVALUATION REPORTS

# THE CLARK HILL LAKE PROJECT

## INTRODUCTION

### Location

The Clark Hill Lake project is located on the Savannah River between Georgia and South Carolina. The dam is located at mile 237.7 (approximately 22 miles above Augusta, Georgia) and backs water into Columbia, McDuffie, Lincoln, Elbert, and Wilkes Counties in Georgia and Abbeville and McCormick Counties in South Carolina. The 1970 population of the two South Carolina counties was 29,067, and 70,944 persons lived in the five Georgia counties in 1970. Six communities with 1970 populations of greater than 10,000 are located within a 50-mile radius of the approximate lake midpoint (Route 378 bridge). Augusta, Georgia, is the largest nearby community with a 1970 population of 59,864.

Interstate Route 20 passes approximately 15 miles south of Clark Hill Dam and at one point passes within 6 miles of an arm of the lake. Clark Hill Lake is crossed by U.S. Routes 221 and 378 and by State highways at several other locations. Administratively, the project is located in the Savannah District of the South Atlantic Division, U.S. Army Corps of Engineers (CE). Much of the project is bounded on the South Carolina side by Sumter National Forest. A map of the project area is presented in Figure 1.

### Authorization

The project was authorized by the Flood Control Act of December 22, 1944,

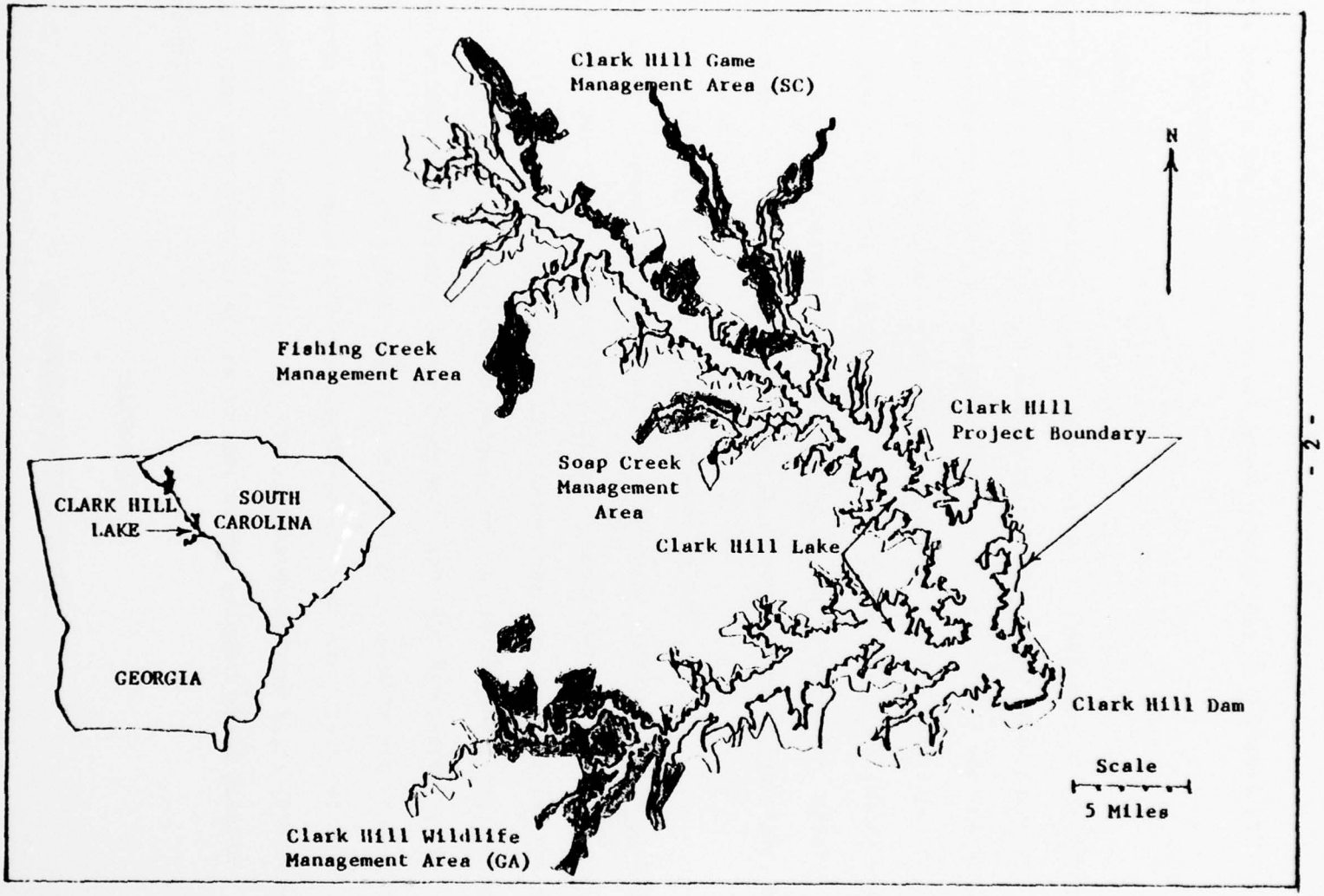


Figure 1. Map of Clark Hill vicinity.

based on the report of the Chief of Engineers in House Document 657, 78th Congress, 2nd Session. The project was authorized to provide power, flood control and navigation benefits.

Physical Features

Construction of the project was begun August, 1946, and completed in July, 1954. The concrete-gravity dam is 695.6 m (2,282 ft) long and 61 m (200 ft) high. The overall length, including earthen embankments, is 1,731.3 m (5,680 ft). The dam impounds a lake 63.4 km (39.4 mi) up the Savannah River, 46.7 km (29 mi) up the Georgia Little River, 27.4 km (17 mi) up the South Carolina Little River, and 10.5 km (6.5 mi) up the Broad River in Georgia.

At the top of the power pool, elevation 101 m (330 ft) mean sea level (msl), the lake covers 28,329 ha (70,000 ac). It provides a total storage capacity of 35.8 x $10^8 m^3$ (2,900,000 ac-ft) allocated as follows: flood control 4.8 x $10^8 m^3$ (390,000 ac-ft); hydroelectric power 12.9 x $10^8 m^3$ (1,045,000 ac-ft); and dead storage 18.1 x $10^8 m^3$ (1,465,000 ac-ft). The total area of the project is 63,087 ha (155,886 ac), including 935 ha (2,311 ac) of flowage easement.

At average recreation pool (elevation 101 m) the project includes 34,138 ha (84,353 ac) of land. At the 101 m elevation, the lake has a shoreline of 1,706 km (1,060 mi) (1). Full flood storage reaches elevation 102 m (335 ft), and covers 31,769 ha (78,500 ac).

Some 14,555 ha (35,965 ac) of Clark Hill project lands have been zoned for wildlife management, with 6,338 ha (15,661 ac) of land and 1,860 ha

(4,597 ac) of water licensed to the Georgia Game and Fish Division and 5,185 ha (12,812 ac) of land licensed to the South Carolina Wildlife and Marine Resources Department as wildlife management areas (2).

Although a minimum navigation flow of 5,800 c.f.s. is required below Augusta, a discharge of 6,300 c.f.s. is normally provided 80 percent of the year. The project is designed with a maximum drawdown of 18 ft (to an elevation of 312 ft msl) (3).

Area Description

The Clark Hill Reservoir project is situated in the Piedmont region of South Carolina and Georgia. The rolling hill terrain typical of the project area is deeply dissected by the Savannah River and its tributaries. The vegetation of the region consists of mixed pines and hardwoods in the uplands, and bottomland hardwoods along the river bottoms. The most common pines are loblolly and shortleaf which exist either as pure stands or as a mixture. The pine-hardwood forest is prominent on areas where pure pine stands were harvested in the past. Some oak-hickery stands are found at lower elevations (2). The soils of the upland consist of sand and clay which are subject to severe erosion. The soils are suitable for the production of several agricultural crops.

Descriptive Reports

The Clark Hill Lake project was constructed near the beginning of the Fish and Wildlife Service's (FWS) water development projects evaluation program. The project was selected for evaluation under the present study partially for this very reason -- to reflect differences in approach

and results between the earlier period of analyzing fish and wildlife resources and the more recent evaluation period. Also, Clark Hill was one of only two projects having both pre-impoundment and post-impoundment fish and wildlife data in the CE's South Atlantic Division.

Due to the project's age, it proved to be extremely difficult to locate some of the pertinent preconstruction planning reports. The 20-year-old FWS documentation could not be located by FWS personnel at either the Decatur, Alabama, field office or at the central office in Washington, D.C. Most of the pre-impoundment information which was found was located in the National Archives in Washington, D.C.

The FWS predictive planning report was released in July of 1946 (4). In December of 1960, the FWS released a follow-up report for the project (5). The 1946 report provided estimates of existing fish and wildlife resources and predicted the impact which the project would have on those resources. A development plan to mitigate losses to the fish and wildlife resources was also presented. The 1960 follow-up report reviewed the record of implementation for the mitigation recommendations which were provided in the 1946 report.

Post-impoundment fish and wildlife information was obtained from the appropriate offices and personnel of the Georgia Game and Fish Division (GFD) in Atlanta, the South Carolina Wildlife and Marine Resources Department (WMRD) in Columbia, South Carolina, and the Savannah District of the CE.

## WILDLIFE RESULTS AND DISCUSSION

### General Discussion

The pre-impoundment predictive document, released by the FWS in July, 1946, discussed the wildlife resources of the project area within the general sections of upland game, fur animals, and waterfowl. Big game was mentioned in the upland game section.

The FWS developed their planning report using engineering data presented in the CE's Definite Project Report, dated December 1, 1945. These data assumed that the full power pool would inundate approximately 8,000 acres more than it actually did and that the flood pool would cover some 19,500 acres more than actually occurred. The preliminary engineering data used by the FWS and the corrected data supplied subsequently by the CE are compared in Table 1.

On September 24, 1947, the CE provided the FWS with the corrected engineering information and asked for any revisions in the estimates of the reservoir's impact on fish and wildlife resources (6). Other than a proposal, and continuing discussion of a possible national wildlife refuge for the benefit of geese (this proposal dropped by the FWS in 1950), corrected projections were never provided by the FWS.

The evaluation of terrestrial wildlife planning projections and planning recommendations are those contained in the 1946 report. Evaluations of the waterfowl resource cover the subsequent planning discussion involving the refuge proposal.

Table 1. — Elevations and acreages used by FWS to develop their 1946 predictive report for the Clark Hill Reservoir project and actual completed project parameters

| | 1946 FWS report | | Actual project | |
|---|---|---|---|---|
| | Elevation | Acreage | Elevation | Acreage |
| Average | 330 | 70,000 | 328* | -- |
| Full power | 335 | 78,000 | 330 | 70,000 |
| Flood | -- | 98,000 | 335 | 78,500 |

* Approximate

Upland Game Resources -- Pre-impoundment Predictions

The pre-impoundment upland game resource descriptions, post-impoundment predictions, and the methods employed by the FWS to develop these predictions are presented in the following section. The 1946 report (4) described the pre-project upland game resources and expected impacts of project construction as follows:

> Upland wildlife species in the general vicinity of the proposed reservoir include gray squirrels, fox squirrels, cottontail rabbits, bobwhite quail and mourning doves. There are no turkey or deer in the area at present. Gray and fox squirrels are common in the boundaries of the area under consideration, and are the most important game animals in this region. Cottontail rabbits are also common, primarily in the vicinity of the agricultural area. There are a few swamp rabbits in the lowlands along the flood plain of the Savannah River. Bobwhite quail are common in the agricultural areas of upland adjacent to the reservoir, but are quite scarce in the lowlands, which are subjected to flooding. They are important game species and are subjected to considerable hunting pressure both by the natives of the region and non-resident sportsmen. Mourning doves are also common in this region, utilizing the agricultural area for feeding and forest areas for nesting and roosting.

Construction of the Clark Hill project was expected to seriously impact the upland game resources of the project area. As described previously, the extent of permanent inundation was expected to be approximately 11% greater than actual occurrence. The upland game resources in the project area following construction were described as follows:

> The proposed Clark Hill Project will completely destroy 78,000 acres of upland game habitat by clearing and inundation. An additional 20,000 acres between the top of the power pool and top of the maximum flow will be subjected to periodic flooding and damaged to the extent of 10 percent of its present value. Quail, rabbit, dove, and squirrel populations forced to retreat to the uplands will compete with the resident game populations of that area for food and cover and will be reduced to the carrying capacity of the land. Experience in game management indicates that this wildlife will be lost ultimately.

> The extent of habitat lost or damaged in the power pool area and in the area between the top of the power pool and maximum flow is summarized in Table 3. There will be no compensatory values to upland wildlife that would offset these losses to any appreciable extent.

Table 2 reproduces the information contained in the referenced third table of the 1946 predictive report. An upland game loss valued at $36,800 was expected to result from the construction of the Clark Hill Lake project.

The basic data files, which illustrate the methods used to develop the various FWS predictions, were located at the National Archives in Washington, D.C. (7). The technique used by the FWS in 1946 was to multiply the potential population of each species on the impacted area by the percent potential harvest. This provided an estimate of the potential annual harvest of each species forgone by reservoir construction. The potential harvest losses by species were assessed unit values based on the average expenditures by sportsmen per unit of game harvested to arrive at a monetary estimate. Table 3 reproduces the upland game computations contained in the basic data files. The dollar value of $39,310 differs slightly from the $36,800 figure used in the 1946 report. This resulted partially from reducing the magnitude of the projected losses in the 20,000 acre flood pool from 50 percent to 10 percent.

The projected 10 percent upland game loss in the flood storage zone would have translated into a potential harvest loss of 500 squirrels, 400 rabbits, 200 quail and 80 doves for the total 20,000-acre flood pool. This represents the loss of 1 squirrel per 16 ha (40 ac), 1 rabbit per

Table 2.— FWS evaluation of annual loss projections for upland game as a result of construction of the Clark Hill Lake project.

| Impacted area | Acres affected | Value per acre | Percent loss | Total loss |
|---|---|---|---|---|
| Power pool | 78,000 | $ .46 | 100 | 35,880 |
| Flood pool | 20,000 | .46 | 10 | 920 |
| Total loss | | | | 36,800 |

20 ha (50 ac), 1 quail per 40 ha (100 ac) and 1 dove per 101 ha (250 ac) of flood storage pool.

No specific discussions were contained in the 1946 report relating to the mitigation of losses to the project associated upland game resources, although a general recommendation to establish suitable game management units was made. There was no elaboration on this recommendation or discussion of the benefits to be derived from its adoption. The report also recommended that all timber to an elevation 1.5m above maximum power pool be cut and removed.

After the FWS withdrew their request for project lands, upon which to create a national wildlife refuge, Georgia requested that the subject lands be zoned for wildlife management under GFD control.

It should be noted that no predictions were either required or made with regard to non-game, or endangered species.

*Upland Game Resources -- Post-impoundment Occurrences*

No comprehensive inventory of upland game resources within the Clark Hill project boundaries was available. Neither was there available any existing estimate of hunter utilization of the upland game resources on project lands. Estimated hunting pressure values for the total project were developed during discussions among knowledgeable local biologists and law enforcement officers. It was necessary to develop resource utilization estimates for three geographical areas and combine these figures to produce an estimate representing the total project. The three areas were: (1) the Clark Hill Wildlife Management Area in Georgia; (2) the remaining CE owned public hunting areas on the Georgia side of the project, and (3) the CE owned public hunting land on the South Carolina side of the pro-

ject, some of which was licensed to the state of South Carolina as part of the State operated Clark Hill Game Management Area.

South Carolina's Clark Hill Game Management Area centers on about 4,856 ha (12,000 ac) of CE land but also includes some Forest Service and paper company lands. The biologist in charge of the area indicated that the wildlife statistics for the Clark Hill Game Management Area would be equivalent to the total CE holdings on the South Carolina side of the project (Robert Gooding, pers. comm., 1976).

As small game hunters were not required to check through the check station on Georgia's 6,071 ha (15,000 ac) Clark Hill Wildlife Management Area, precise values for upland game hunting effort were not available. The average season for upland game on the Clark Hill Wildlife Management Area runs around 23 days. It was estimated an average of only 10 hunters were afield on this area per day, resulting in an estimated total effort of approximately 230 hunter-days annually for upland game species on the area (David Waller, pers. comm., 1976).

The remaining project lands on the Georgia side are hunted much more intensively for upland game. After discussions with state biologists and law enforcement officers, the CE game biologist estimated the annual upland game hunting pressure at approximately 12,000 man-days for the 12,141 ha (30,000 ac) open to public hunting.

Use of CE lands in South Carolina by upland game hunters was estimated at an intensity intermediate between the two Georgia tracts. The estimate

was based solely on experience and judgment of the involved state and federal biologists. No studies or check station data are available for any species on the South Carolina side of the project. The effort estimate provided from the state and federal people was 2,700 man-days of upland game hunting on the approximately 8,094 ha (20,000 ac) of public hunting land in South Carolina (Dave Brady and Robert Gooding, pers. comm., 1976).

The total upland game hunting effort estimate for the approximately 2,550 ha (63,000 ac) of public hunting lands around the Clark Hill Lake project was 14,930 man-days annually.

No harvest statistics were available. Squirrels were identified as the dominant target species in Georgia, while quail and raccoons were said to be hunted more frequently on CE property in South Carolina.

Big Game Resources -- Pre-impoundment Predictions

One of the most interesting aspects of the Clark Hill Lake project, from the fish and wildlife point of view, was the establishment and expansion of the big game community during the years subsequent to project construction. Neither deer nor turkey inhabited the project area in 1946, and no potential for their establishment was foreseen (4). Mention of the pre-impoundment big-game situation was restricted to a simple sentence in the FWS planning report, viz:

> There are no turkey or deer in the area at present.

Big game was not mentioned in the post-project predictive section of the

formal report. The basic data materials (7) which were developed to permit preparation of the formal planning report discussed this aspect in somewhat greater scope. Clearly indicative of the conventional wisdom prevailing in 1946 is the following statement concerning big game in the project area:

> Turkeys and deer were formerly very abundant, but the habitat is so interspersed with farm land that it is no longer suitable.

The future for big game animals was considered to be as bleak, and was described as follows:

> There are no turkey or deer at present and the possibility of restoration seems limited. The key habitat of these species will be limited after impoundment. Valleys are narrow and are not considered excellent habitat for these species. After impoundment no suitable habitat will be available to absorb the populations.
>
> * * *
>
> The surrounding upland is heavy cut-over, or in cultivation; therefore, the opportunity for the establishment of refuges for deer and turkey is practically nonexistent.

This dire projection was reflected in the tabular presentation of expected upland game losses. This material is reproduced in this report as Table 3.

Big Game Resources -- Post-impoundment Occurrences

As a result of the loss of forest habitat, plus excessive and illegal hunting, deer had become virtually extinct in Georgia by around the turn of the century. Efforts to reestablish white-tailed deer in Georgia by selective restockings began in the late 1920's. The first herds were established in the mountainous counties, and hunting was permitted

Table 3. — FWS's basic data used to formulate estimated upland game loss associated with construction of the Clark Hill Lake project

| Species | Acres of habitat top power pool | Potential carrying capacity acres per animal | Potential population | Potential annual harvest | | | | Estimated potential benefits to lands adjacent to reservoir |
|---|---|---|---|---|---|---|---|---|
| | | | | Percent | Number | Unit value | Total value | |
| Squirrel | 78,000 | 4 | 19,500 | 50 | 9,750 | $1.00 | $ 9,750.00 | None |
| Rabbit | 78,000 | 5 | 15,600 | 50 | 7,800 | 1.00 | 7,800.00 | " |
| Deer | - | - | - | - | - | - | - | " |
| Quail | 78,000 | 10 | 7,800 | 40 | 3,120 | 5.00 | 15,600.00 | " |
| Dove | 78,000 | 25 | 3,120 | 50 | 1,560 | 1.00 | 1,560.00 | " |
| Turkey | - | - | - | - | - | - | - | |
| | | | | | 22,230 | | 34,710.00 | |
| Total | 78,000 | | 46,020 | | | | | None |
| (Annual value of habitat loss (top of power pool) per acre - $0.46) | | | | | | | | |
| Annual value of habitat loss in surcharge area (20,000 x .23) | | | | | | | 4,600.00 | |
| Total annual loss of upland game values in reservoir . . . . . | | | | | | | 39,310.00 | |

in some areas by the early 1940's (8).

Since 1946, the immediate project area, as well as extensive areas of the Southeastern U.S., has undergone dramatic changes in land use. These changes have been typified by a gradual transition of agricultural lands to grazing and timberlands. Deer and turkey populations have benefited from the trend to reforestation.

Seven years after release of the FWS report, a statewide inventory of big-game resources in Georgia indicated that the counties bordering the Clark Hill project area supported minimal deer and turkey populations. McDuffie was the only county of the five bordering the project that was listed as having a deer herd (estimated at 10 head). Lincoln County was the only county identified as possessing a turkey population (10 birds) (9).

White-tailed deer were introduced into Georgia's Clark Hill Wildlife Management Area in 1951. Between 1951 and 1953, a total of 58 deer were released on the Management Area. Reintroduction of white-tailed deer on or near project lands in South Carolina also began in 1951.

Unfortunately, no comprehensive wildlife inventories or utilization studies have been conducted by either the Georgia GFD or the South Carolina WMRD. Estimates of the present deer and turkey populations on Clark Hill project lands were developed from information provided by biologists working on the area. The average number of deer was estimated at 78 per $km^2$ (30 per $mi^2$) in Georgia and approximately 91 per $km^2$ (35 per $mi^2$) in

South Carolina. These estimates were based on track-count studies (David Brady, pers. comm., 1976). Using an average figure of 83 deer per $km^2$ (32 per $mi^2$) the estimated number of deer on the 254 $km^2$ (98 $mi^2$) of public lands open to hunting approximates some 3,140 animals.

Turkey populations on Clark Hill project lands were estimated at around 20 per $km^2$ (8 per $mi^2$) on the Georgia side and 18 per $km^2$ (7 per $mi^2$) on the South Carolina side. Assuming an average of 19 birds per $km^2$ (7.5 per $mi^2$) for the 254 $km^2$ of hunting lands, a turkey population of 735 birds was estimated on Clark Hill project lands. The number of turkeys in the five surrounding Georgia counties was estimated at approximately 5 birds per $km^2$ (2 per $mi^2$) in a study covering the period 1972 to 1974 (10).

As described in the upland game section, hunting pressure and harvest statistics were available from three separate land tracts: Georgia's Clark Hill Wildlife Management Area; the remaining CE lands in Georgia; and the project lands in South Carolina, including South Carolina's Clark Hill Game Management Area.

Check stations located on Georgia's Clark Hill Wildlife Management Area provided the best estimates of big game hunting effort and harvest. The Clark Hill Wildlife Management Area usually has 17 days of managed deer hunting and 6 days of managed turkey hunting. Hunters must purchase a special permit and check their game. An average of 1,017 deer hunting permits were sold each year over the 12 year period 1964 to 1975. Studies by state biologists indicated that the average big game

hunting permittee hunted three days per season. Multiplying the 1,017 hunters by 3 days provides an estimate of 3,050 man-days of deer hunting annually on the Clark Hill Wildlife Management Area. The average number of deer harvested per year was 160.

Turkey hunting information for the Clark Hill Wildlife Management Area was provided by Georgia GFD staff for six seasons (1967-69, 1973, and 1975-76). Turkey hunting was permitted every year during the period 1967 to 1976, but data were not available from the state for each year within this period. An average of 87 turkey hunting permits were sold over the six seasons. At the suggestion of Georgia biologists, a figure of three hunter-days hunting per permit holder was used to estimate the total turkey hunting effort. The total average turkey hunting effort on the Clark Hill Wildlife Management Area was estimated at 260 (rounded) hunter-days annually. Turkey harvest for the six seasons ranged from 7 in 1975 to 2 each in 1969 and 1976. On the average, four turkey were harvested annually from the area.

Big game hunting pressure estimates for the remaining CE-owned project lands in Georgia were developed especially for this evaluation by Georgia GFD biologists and law enforcement officers in cooperation with the project biologists for the CE. This approximately 12,141 ha (30,000 ac) area supports an estimated hunting effort of 4,000 man-days per year by deer hunters, with a harvest of 300 animals. Also, 300 man-days are expended by turkey hunters, with a harvest of 21 birds.

Hunting effort estimates for the Clark Hill project lands in South Caro-

lina are provided annually at CE project staff request by the South Carolina WMRD biologist responsible for the project area. Estimates used in this evaluation of project planning were based upon the latest available letter-report (11) and an indication from the biologist that hunting pressure exerted on the area remains at approximately the same level (Robert Gooding, pers. comm., 1976).

According to these data and subsequent discussions, approximately 2,400 hunter-days were spent by deer hunters on project property in South Carolina with the subsequent harvest of 170 deer. Turkey hunters spent an average of 300 hunter-days hunting Clark Hill project lands and harvested around 16 birds per season. These estimates represent educated guesses made by the local biologist based on his resource management experience on the area. No formal studies have been conducted to quantify hunting pressure or harvest on the Clark Hill project lands.

Summing the three separate estimates for Clark Hill project lands provided an estimated hunting effort totalling 9,450 hunter-days for deer and 860 hunter-days for turkey. The total annual harvest estimates for the Clark Hill project was 630 deer and 41 turkeys.

Waterfowl Resources -- Pre-impoundment Predictions

A review of the waterfowl resource planning performance at the Clark Hill Lake project revealed several inconsistancies in the planning recommendations. Immediately prior to the release of the FWS planning report in July, 1946, a separate evaluation of the waterfowl development potential was prepared (12). This report concluded that:

> After a survey of the proposed Clark Hill Reservoir, it is believed that the area is unsuitable for the establishment of a Federal goose refuge. Two areas, which offer possibilities as goose refuges are discussed, though it is believed that their development will require a considerable expenditure of money. A plan, which involves State and Federal cooperation, is proposed. No effort has been made to estimate the probable cost of developing a goose refuge under any of these plans, nor is it believed feasible to estimate the number of geese, which might use these areas, if they were developed.

At about the same time, a FWS refuge management biologist also recommended against development of a waterfowl refuge in conjunction with the Clark Hill Lake project (13). The proposal was opposed since land acquisition to the 350 feet msl contour (with an expected occasional flood rise to the 346 feel level) would result in less than satisfactory food-production potential for migratory waterfowl.

The Division of Wildlife Refuges at the Washington, DC, office level maintained an interest in the development of a refuge on the project, and even after release of the 1946 report drafted correspondence disclaiming the previously-mentioned evaluations (14). The refuge proponent's position was accepted, as reflected in the 1946 FWS report which described the area's waterfowi resources with the following statement:

> Clark Hill Project area and adjacent lands are used to a moderate degree by waterfowl during the migratory season. Species of ducks reported in the vicinity include: mallard, black duck, green-winged teal, pintail, lesser scaup, baldpate, canvasback, redhead, and wood duck. Of these, perhaps the most numerous is the wood duck, which occasionally may be found nesting along the Savannah River, and which is supplemented by migrants in the early fall. Canada geese and snow geese are also reported in this area, although they do not remain long in the vicinity of the Savannah River during the migratory season. According to estimates, the population of geese in the project area varies from 125 to 500. There are no waterfowl hunting clubs in this locality.

> The Clark Hill area provides some of the best waterfowl hunting in the State of Georgia. It has been noted that waterfowl use the river for nesting, and feed in the adjacent lowlands and in the agricultural lands of the uplands.

Waterfowl resources were more carefully and fully considered than other wildlife populations in the section dealing with anticipated impacts of reservoir construction. The projected use of the area following project construction was described as follows:

> With the completion of the project, a total of 110 miles of stream and adjacent lowlands now utilized by wild ducks and geese will be replaced by a permanent water area of approximately 78,000 acres. It is expected that more ducks will use this reservoir than are now using the Savannah River and its tributaries within the project area. The total number of ducks and geese using the reservoir, however, will be limited to a great extent by the food supply. There will be little aquatic vegetation in the lake, nor are there attractive feeding grounds in the adjacent uplands. Some duck hunting will be afforded in the inlets and bays, but for the most part the ducks will remain inaccessible to the hunters.
>
> The reservoir may be used as a resting area for wild geese. As already noted, some 125 to 500 geese use the Savannah River within the project area during the migratory season. The reservoir is located on an important goose flyway, so that intensive management would attract and hold a larger number of geese in the vicinity of the reservoir. As there will be few aquatic plants, foods would have to be planted along the shores or in the uplands adjacent to the impoundment.
>
> Estimated losses and benefits (without management) to waterfowl are summarized in Table 5.

The referenced table of the predictive report has been reproduced as Table 4 in this report. The methodology used to develop the predictions was not recorded in any of the documentations located. The monetary value of the waterfowl resource was expected to increase some nine-fold as a result of reservoir construction. It should be noted that the expected

Table 4.-- Evaluation of losses and benefits to waterfowl as projected by the FWS for the Clark Hill Lake project

| Pre-project | | | Post-project | | | |
|---|---|---|---|---|---|---|
| Miles of streams to be flooded | Value per mile | Value of streams | Area of reservoir | Value per acre | Value of reservoir | Net gain |
| 110 | $20 | $2,200 | 78,000 | $0.25 | $19,500 | $17,300 |

full power pool was 8,000 acres or 11 percent larger than the dimensions of the actual project.

Three of the eight recommendations provided by the FWS dealt directly with the waterfowl resources. The 1946 report recommended that a sub-impoundment be established to encourage waterfowl use. Six potential sites in Georgia and one site in South Carolina were described in the report. The second and third waterfowl-related recommendations were to establish and manage a national wildlife refuge and state game management unit at the project.

With regard to the refuge recommendation, the 1946 report stated:

> The area has a high potentiality for wildlife conservation purposes and its attractiveness for wild ducks and geese would be increased through the establishment of a Federal wildlife refuge and State wildlife management areas. Through intensive management suitable feeding and resting areas for geese and ducks could be established. This would require the selection of lands for planting grains and winter greens; the establishment of one or more sub-impoundments, and providing sufficient lands under adequate protection.
>
> The Fish and Wildlife Service proposes to make further investigations which will form the basis of final determination of the location and size of the area suitable for National refuge purposes. Preliminary investigations indicate that the best site for such a refuge consists of 20,000 acres on the upper extremities of the reservoir, from Highway 70 north-westward to the upper end of the impoundment, including all upland holdings and one or more sub-impoundments.

The CE responded to the 1946 FWS report by indicating that the actual take line had not yet been established and that, "a map of the reservoir area showing the reservoir take line will be furnished your office when the mapping of the reservoir for land acquisition is completed." The

master plan was being developed by the CE during this period. To assist the CE in their function, the Service was requested to conduct further investigations to determine the location and size of the area suitable for refuge purposes.

Continued discussions between the construction agency and the FWS related to the refuge proposal. On August 11, 1948, the FWS submitted correspondence to the CE which expressed their "definite" interest in the establishment of a refuge in conjunction with the Clark Hill project (15). The area proposed at this time was along the north shore of Little River, in Georgia, and was approximately 12,440 ha (30,740 ac) in size. According to the FWS, this area was selected for the refuge for the following reasons:

> In selecting this boundary, we have tried to anticipate your probable acquisition line. We have included a minimum area which would encompass desirable habitat type and cleared fields which would be particularly useful in waterfowl management.

In October, 1950, the FWS withdrew their request for a waterfowl refuge on the Clark Hill Lake project (16). This decision was based on a new CE timber-clearing plan involving a reduction in the acreage proposed for clearing. As a result, the Service concluded that the area under consideration would not contain sufficient acreage of cultivable agricultural land between the reservoir shoreline and the acquisitional boundary.

A summary of the FWS actions relative to the development of a federal wildlife refuge was contained in the FWS follow-up report released in

1960 (5), viz:

> A strong desire for a refuge was expressed by the Branch of Refuges (memo May 2, 1946, Salyer). The location was found to be undesirable by biologists of both the Branch of River Basin Studies and Branch of Refuges (report June 19, 1946, Pierce; memo June 18, 1946, Baldwin). The establishment of a refuge and construction of a sub-impoundment were recommended at the request of the Branch of Refuges (memo March 17, 1948, Fredine). The Corps bought all lands requested in our recommendations with the exception of 700 acres (memo to Central Office February 23, 1949, Silver), modified their plans for development of Bussey Point Tent Area, and included the refuge in their master plan (letter District Engineer, February 21, 1950). Request for the refuge was withdrawn by the Service (letter to District Engineer, October 17, 1950, Silver).

Waterfowl Resources -- Post-impoundment Occurrences

Development of the Clark Hill Lake project for waterfowl and waterfowl hunting was obviously retarded by the decision which precluded development of a national wildlife refuge. Several smaller scale waterfowl development programs have been carried out by the states.

The South Carolina WMRD has established the 121-ha (300 ac) Clark Hill Waterfowl Development. Pens have been constructed and rearing activities are underway which will hopefully result in establishing a resident breeding flock of Canada geese. Some 5 to 8 ha ( 10 to 20 ac) of the development are planted annually with corn and wheat to provide waterfowl food. This management activity on the waterfowl area is designed to hold a wintering population of ducks and geese to improve waterfowl hunting. Waterfowl hunting on the South Carolina side is limited and was estimated to approximate 200 man-days per year (Robert Gooding, pers. comm., 1976). Georgia has a similar program underway to establish a resident nesting population of Canada geese.

Most waterfowl hunting on Clark Hill Lake occurs on the Georgia side as a direct result of more intensive waterfowl management. The 809-ha (2,000 ac) Fishing Creek management area which is operated by the Georgia GFD, is a prime waterfowl hunting location. A total of 8 ha (20 ac) of waterfowl impoundments have been developed on the Fishing Creek property.

The extent of waterfowl hunting on the entire Georgia side of Clark Hill Lake was estimated to be around 1,820 man-days per year. No estimate of duck or goose harvest or of the extent of migratory bird utilization was available from either state or CE personnel.

In the last 10 or 15 years, the beaver population of the project area has increased greatly. As a result, the proliferation of beaver ponds on and near project lands, have provided subimpoundment-type habitat which has benefited certain waterfowl species, particularly wood duck. Some of the beaver ponds are drained, planted with waterfowl food plants, and re-flooded. CE biologists have also installed approximately 150 wood duck nesting boxes on project lands.

Furbearer Resources -- Pre-impoundment Predictions

Although no post-construction quantitative data are available for comparative evaluation, the furbearer resources received careful consideration during the preconstruction deliberations and these data are presented for illustration of the methodology used. A qualitative description of the Savannah River furbearer community was presented as follows:

> Fur animals in the vicinity of the reservoir include opossum, mink, muskrat, skunk, civet cat, weasel, gray fox, red fox, bobcat, and raccoon. There are no records available on the

> fur catch within this region, but it is evident that trapping and hunting fur animals have afforded the residents of this region a supplementary source of income. The total fur harvest of this area is low and not of great economic importance compared with the productive marshes of Louisiana or lower swamps of the Savannah River.

Impoundment of Clark Hill Lake was expected to result in the loss of 31,567 ha (78,000 ac) of furbearer habitat. Some increase in carrying capacity for certain species of furbearers was expected, however. The overall impact of lake construction on the resource was described in the following words:

> At the maximum power pool level, 78,000 acres of fur animal habitat will be inundated. The area between the top of the power pool and maximum flow will not be decreased in value as a fur animal habitat, inasmuch as it will be used as a feeding area.
>
> The completion of the project and the impoundment of water will create an irregular and extensive shoreline, which properly protected and managed, should improve the productivity of the land adjacent to the impoundment. It is expected that mink will increase along the shore line of the proposed impoundment, but this increase will not be sufficient to justify the assignment of a substantial value to the potential benefits of the reservoir.
>
> A summary of annual losses and benefits is given in Table 4.

The referenced table is reproduced as Table 5 herein. The calculations employed by the FWS to derive furbearer predictions are reproduced from the basic data files as Table 6. The technique was similar to that used for upland game, i.e., estimated carrying capacity multiplied by potential annual yield percentages and assigning a unit monetary value. The assigned monetary values for fur were probably estimated prices paid by local fur buyers.

Table 5. -- Evaluation of losses and benefits to fur animals as projected by the FWS for the Clark Hill Lake project.

| Pool | Acres affected | Value per acre | Loss | Estimated potential | |
|---|---|---|---|---|---|
| | | | | Benefits | Loss |
| Power pool | 78,000 | $0.045 | $3,510 | $600 | $2,910 |

Table 6. — Basic calculations used by FWS to formulate estimated furbearer loss associated with construction of the Clark Hill Lake project

| Species | Acres of habitat top power pool | Potential carrying capacity acres per animal | Potential population | Annual potential harvest | | | | Estimated potential annual benefits of reservoir |
|---|---|---|---|---|---|---|---|---|
| | | | | Percent | Number | Unit value | Total value | |
| Opossum | 78,000 | 20 | 3,500* | 50 | 1750* | $ .50 | $875.00* | None |
| Raccoon | " | 100 | 780 | 20 | 156 | 3.00 | 468.00 | 234.00 |
| Mink | " | 150 | 520 | 15 | 78 | 6.00 | 468.00 | 351.00 |
| Muskrat | " | 100 | 780 | 30 | 234 | 1.25 | 202.50 | None |
| Beaver | " | 500 | 29* | 20 | 6* | 15.00 | 90.00* | -- |
| Skunk | " | 50 | 1,560 | 30 | 468 | 1.25 | 585.00 | -- |
| Civet Cat | " | 100 | 780 | 30 | 234 | .75 | 175.50 | -- |
| Weasel | " | 200 | 390 | 15 | 58.5 | .50 | 29.25 | -- |
| Otter | " | 3,900 | 20 | 15 | 3 | 15.00 | 45.00 | 15.00 |
| Fox - Gray | " | 75 | 1,040 | 20 | 208 | 1.75 | 364.00 | -- |
| Fox - Red | " | 1,000 | 78 | 20 | 16 | 5.00 | 80.00 | -- |
| Total | | | 9,477* | | 3,211.5* | | 3,472.25* | 600.00 |
| Annual harvest value per acre (3,474.25* ÷ 78,000) . . . . $0.04 ** | | | | | | | | |

* Mathematical errors identified but not corrected.

** Rounded, actually $0.0445 and increased to $0.045 in 1946 formal report.

Furbearers Resources -- Post-impoundment Occurrences

No harvest records are available for furbearers. A list of those furbearers that occur in the Clark Hill Lake area was provided by Georgia game biologists (David Waller, pers. comm., 1976). The list included: beaver, otter, muskrat, mink, red fox, grey fox, raccoon, opossum, bobcat, spotted skunk and striped skunk.

During the field investigation it was pointed out that greater beaver activity on project lands has resulted in increased pond habitat acreage (David Brady, pers. comm., 1976). Some of these shallow beaver ponds are being managed (drained, planted and refilled) to provide enhanced waterfowl habitat. All of the beaver ponds provide resting areas for waterfowl.

Wildlife Resources -- Evaluation of Planning Input

An unusually liberal land acquisition policy for lands above the normal storage elevation created beneficial terrestrial wildlife habitat at the Clark Hill project. Clark Hill Lake project lands, with a total surface area of 63,087 ha (155,886 ac) can be divided into three general areas with respect to wildlife resources. The largest is the 28,329 ha (70,000 ac) area inundated by the normal pool. Approximately 25,500 ha (63,010 ac) of surrounding terrian, including the lands licensed to state agencies for wildlife management, are opened to public hunting. The remaining 9,262 ha (22,886 ac) of project lands includes the more intensively developed recreational and administrative lands.

In their planning report of 1946, the FWS dealt exclusively with those lands expected to be inundated by Clark Hill Lake, although the report

included a recommendation for the development of publicly-operated game management areas on project lands. It was apparent, therefore, that the planners believed that project lands not inundated offered some potential for beneficially impacting wildlife. In spite of this consideration and subsequent recommendation to dedicate certain lands to wildlife management, no quantitative post-impoundment projections were provided for the wildlife resources on project lands above the limits of flood water storage. This omission is considered to have been a major deficiency of the report.

In spite of this obvious planning deficiency, it was possible to evaluate the approaches taken and tools used to develop wildlife planning recommendations and post-impoundment projections.

Upland game resource impacts were based upon carrying capacity estimates of the habitat and associated potential harvest of individual forest game species, and the amount of this habitat expected to be lost (Table 3). This is considered to have been a solid point of departure for impact assessment. The predictive technology utilized in the 1946 report transformed the potential harvest estimates into monetary values without providing estimates of hunter-days in the process. Unfortunately, post-impoundment upland game population estimates were not available for the 25,500 ha (63,010 ac) of project lands opened to public hunting. The only post-impoundment information available for upland game was the estimated number of hunter-days. Local biologists did not consider it possible to develop meaningful harvest data. Therefore, no direct compari-

son of pre-impoundment projections (harvest only) and post-impoundment occurrences (effort only) was possible.

Since the 1946 FWS report was prepared, a combination of socio-economic influences resulted in a dramatic change in land use throughout the South. This reversion of farm land to forest cover, which began in the early 1950's, had a profound impact on terrestrial wildlife populations. Among the animals most benefited by the development of additional acres of forest cover were turkey and deer. A successful restoration effort for both deer and turkey followed the vegetative changes.

This unforseen transition from farm land to deer and turkey habitat in the Clark Hill project area belied the FWS's 1946 projections. The opportunity for reestablishing big game in the project area was described as "practically nonexistent" in the support data, and the 1946 report itself did not mention big game in the post-impoundment discussion.

The current abundance of big game associated with Clark Hill project lands was estimated at approximately 3,140 deer and 735 turkeys. Recreational hunting supported by big game on project lands was estimated at 10,310 hunter-days per year.

The most active involvement of fish and wildlife concerns (particularly by the FWS) in the pre-construction planning of Clark Hill Lake concerned the creation and management of waterfowl habitat. Opinions among Service personnel varied widely with regard to the potential of Clark Hill Lake to enhance the migratory waterfowl use of the project area.

An opinion expressed early in the planning period by some FWS personnel was that the project area lacked sufficient acreage of cleared fields and, thus, food production potential. Eventually, the FWS did recommend creation of a federal wildlife refuge on Clark Hill project lands, only to withdraw the proposal after a period of approximately four years.

Approximately 125 to 500 geese used the Savannah River within the proposed project boundaries prior to project construction (the amount of duck-use unknown). Although greater use of the area by ducks and geese was expected, the extent of such use was not predicted. Use was expected to be limited due to the lack of waterfowl food-producing areas.

Neither the Georgia GFD nor South Carolina's WMRD have conducted waterfowl migratory utilization or nesting studies on the project. The actual numbers of ducks and geese that use project-created waterfowl habitat are unknown. Both state agencies are making efforts to establish resident nesting populations of geese. There is no known federal effort involving goose management at the project.

Currently, waterfowl hunting provides approximately 2,020 man-days of recreation annually. Most of this hunting occurs on the Georgia side and is associated with the general area of the one artificial sub-impoundment subsequently created on project lands.

An indirect benefit of the fur animal community on project lands has been the creation of sub-impoundment type habitat resulting from the activities of an expanded beaver population. Taking advantage of the beaver

pond habitat, management agencies have erected many wood duck nesting boxes and have drained, planted waterfowl food plants, and reflooded some of the beaver ponds. Fish populations are enhanced by the additional water acreage and the ponds promote improved water quality by trapping sediments.

No post-impoundment data were available to allow determination of the accuracy of FWS furbearer projections. The 1946 treatment of furbearers considered only the area to be lost permanently along with immediate shoreline area.

A summary of the big game, upland game and waterfowl hunter-day and harvest statistics developed during this investigation is presented in Table 7.

Selection of the Clark Hill Lake project for evaluation provided an opportunity to study fish and wildlife planning efficacy at a very early period in the FWS's River Basin Studies (RBS) existence. The Clark Hill predictive report was among the first prepared by RBS and undoubtedly contributed to the establishment of methodologies and format for future evaluations. The federal planning record reflected, in part, the extremely small investigative staff available for planning purposes at the time. State input to Clark Hill project planning was reportedly minimal, as well. The Georgia wildlife biologist for the area containing the project does not recall visiting the site for purposes of providing preconstruction planning input (Jack Crockford, pers. comm., 1976).

An indication of the lack of aggressive activity associated with the Clark Hill planning was the inadequate communication between agencies.

Table 7. — Estimated annual hunting effort and harvest occurring on Clark Hill project lands

| Area | Deer | | Turkey | | Upland game | | Waterfowl | |
|---|---|---|---|---|---|---|---|---|
| | Hunter-days | Harvest | Hunter-days | Harvest | Hunter-days | Harvest | Hunter-days | Harvest |
| CHWMA[1] (GA) | 3,050 | 160 | 260 | 4 | 230 | - | 0 | 0 |
| CE non-licensed lands (GA) | 4,000 | 300 | 300 | 21 | 12,000 | - | 1,820 | - |
| CHGMA[2] (SC) | 2,400 | 170 | 300 | 16 | 2,700 | - | 200 | - |
| Totals | 9,450 | 630 | 860 | 41 | 14,930 | - | 2,020 | - |

1. Clark Hill Wildlife Management Area

2. Clark Hill Game Management Area

During the four-year period of communications and discussions between the FWS and the CE, the FWS seemed to be operating under the handicap of not having adequate or current information from the construction agency regarding land acquisition and timber clearing plans. Project engineering data available to the FWS in 1946 showed a power pool some 3,238 ha (8,000 ac) larger than the final project design. Although they were notified about the engineering changes in 1950, corrected wildlife projections was not forthcoming from the FWS. An internal FWS memorandum of March 24, 1950 (17), shed some light on this decision by the FWS not to compile updated data. The memorandum informed the Regional FWS Director that no evidence could be found to indicate that the CE had utilized the previously provided fish and wildlife values for justification of construction funds for the project.

Wildlife management areas under license to Georgia and South Carolina total 12,140 ha (29,998 ac) on the Clark Hill Lake project. The historical documentation indicates that the states and not the FWS played the lead roles in identifying and obtaining these land areas from the CE. When the federal wildlife refuge proposal was withdrawn in 1950, the communications between the federal agencies nearly ceased for a period of several years.

In summary, the fish and game agencies' projected wildlife figures were of little consequence to project planning or construction. Wildlife planning was perfunctory, and seemingly served merely to fulfill the fish and wildlife and construction agencies' obligation to communicate. No

evidence points to a serious effort to incorporate wildlife as a legitimate component of project planning.

## FISHERY RESULTS AND DISCUSSION

### Fishery Resources -- Pre-impoundment Predictions

A poor quality fishery apparently existed in the Savannah River and its tributaries prior to Clark Hill project construction. Turbid water was presented as the major cause of this poor fishery. The FWS pre-construction report (1946) described the fisheries of the Savannah River system within the proposed project area as follows (4):

> The principal species of fish in the main stream of the Savannah River in the vicinity of the project area are blue catfish, crappie, yellow or speckled catfish, largemouth bass, bluegill, red breast sunfish, long-nosed gar, and carp. In the tributaries of the Savannah River, these species, as well as wall-eyed pike and warmouth bass, are reported.
>
> Fishing in the Savannah River is not important because the waters are turbid during most of the year, and especially during the summer, when heavy rainfall floods the narrow valley. The type of fishing is limited for the most part to the use of live bait and the principal species taken are catfish, crappie, and sunfish. The production of fish in the river is limited by the effects of long periods of muddy water which prevent the growth of plants (algae and the larger aquatic plants) by a shifting sand bottom, and by the virtual absence of gravel and rubble in the long riffles where bedrock is exposed.
>
> Fishing conditions are better in the tributaries, such as Little River (Georgia), Little River (South Carolina), and Pistol Creek, but even here the production of the streams is greatly decreased by the turbidity of the water following periods of heavy rainfall. There is little fishing in Broad River, Long Cane Creek, Fishing Creek, and Soap Creek.
>
> There is no commercial fishing of any importance in the streams within the project area. No migratory fish of commercial importance were using the Savannah River in the project area at the time of this survey. According to data obtained during the survey, the Savannah River was used at one time by shad, and they were caught in sufficient numbers to be of economic importance, but it should be mentioned that this stream was apparently never as productive as some of the shad producing waters of other streams along the Atlantic Coast, which are recognized for their commercial fisheries. Use of the Savannah River by shad was

precluded by the establishment of a dam at Augusta, Georgia, in 1847, which was enlarged in 1975. At the time of this writing, there are three existing dams below Clark Hill Project, which prevent the migration of the shad up the Savannah River to the area of the Clark Hill Project. The first of these dams is the new Savannah Bluff Dam at Mile 181.3 with a difference in water elevations above and below the dam of about 15 feet. The second is the Augusta City Dam at Mile 208.6, which is 14 feet high and diverts the water to the Augusta City Power Canal. A third dam is at Stevens Creek, located at Mile 209.7, which is 25 feet high and is designed for power production.

The construction of a large lake at the Clark Hill site was expected to significantly increase fisheries values of the project area. The projected benefits were described in the following manner:

> Completion of the Clark Hill Project will create a reservoir with an average pool of 70,000 acres to supplant the Savannah River and its tributaries within the area inundated. The reservoir will have a shore line of 866 miles at the top of the average pool. Normal fluctuation of the water level for power use will be only five feet. There will not be a great area of water less than six feet deep, inasmuch as the reservoir is rather steep sided. The reservoir will be 154 feet deep at the dam and the water will undoubtedly be roily for a considerable part of the year as the silt load of the Savannah River is great. It is estimated from geological reports that the rate of siltation will be 0.5 acre-feet per square mile per year. On this basis, the dead storage pool, with a capacity of 1,170,000 acre-feet, will fill with silt in approximately 380 years. The construction of other dams on the upper reaches of the Savannah River system will increase the fish productivity of this reservoir and prolong its value by decreasing the rate of siltation and the turbidity of the water.
>
> Stream fishing, as now engaged in by the few sportsmen and residents of the region, will be replaced by lake fishing, which will provide recreation for a much larger number of fishermen. It is estimated that the annual value of the yield of fish from the reservoir will be $180,000. A large percentage of this yield will be composed of such species of fish as the largemouth bass, redbreast sunfish, and crappie. Inasmuch as the water will be roily, it is expected that the reservoir will be suitable for carp, yellow catfish and blue catfish.
>
> The dam will have no adverse effect on migratory fish since the

> movement of such species as may extend into the lower reaches of the river are prevented from moving upstream by the three existing dams already described. With the increased flow of clear water below the dam, more favorable conditions may be created for migratory fish, but unless fishways are provided for these dams, there will be no need for such provision in the Clark Hill Project. The average fluctuation of only five feet should be especially beneficial, although during critical periods drawdown for power may be as much as 25 feet. Increased low flows of the river should serve to alleviate pollution below Augusta, and additional habitat should be created for fish along the Savannah River by maintaining the water level within the river channel and adjacent streams at a slightly higher level. The present silt load of the river below Augusta will be reduced, with beneficial results on the fisheries in this section of the stream. A summary of fishery losses and benefits is shown in Tables 1 and 2.

The referenced tables from the 1946 report have been consolidated and are reproduced herein as Table 8. It should be noted that the narrative used figures of 70,000 acres valued at $180,000 per year while the tabular presentation shows a 78,000-acre figure valued at $190,000.

Monetary values were assigned to the reservoir fishery by means of the von Limbach Curve (Figure 2). This curve, which plotted surface acreage against total expected fishery value in dollars, was based on sport and commercial catch records for a number of lakes and reservoirs. Catch was converted to monetary terms by applying dollar values to certain key species of fish. The dollar values were based on average expenditures by sportsmen, including all money spent in connection with fishing for equipment, transportation, lodging, meals, etc. As examples, largemouth bass were valued at $2.00 per pound, while sunfish were valued at $0.75 per pound.

The FWS developed and submitted several fishery-related recommendations

Table 8.— Evaluation of losses and benefits to fishery resources as projected by the FWS for the Clark Hill Lake project

| Pre-project | | | | Post-project | | | |
|---|---|---|---|---|---|---|---|
| Streams flooded | Miles of streams to be flooded | Value per mile | Value of streams | Area of reservoir | Value per acre | Value of reservoir | Net gain |
| Savannah River | 39.9 | $250 | $ 9,975 | | | | |
| Broad River | 7.0 | 110 | 770 | | | | |
| Little River (SC) | 20.0 | 270 | 5,400 | | | | |
| Little River (GA) | 47.0 | 270 | 12,690 | | | | |
| Total | 113.9 | - | $28,835 | 78,000 | $2.44 | $190,000 | $161,165 |

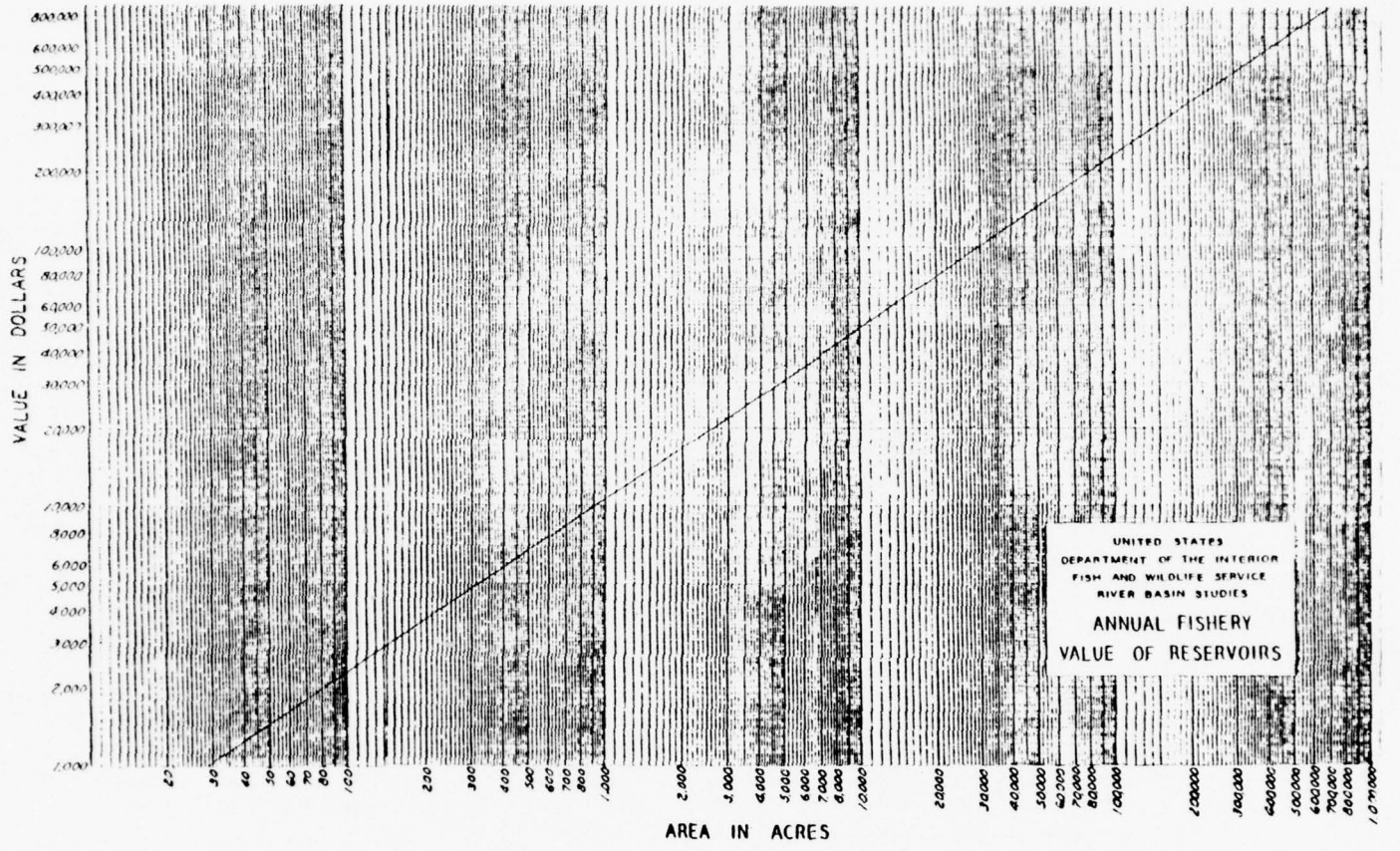


**Figure 2.** **von Limbach Curve used by FWS to develop fishery predictions for Clark Hill Lake.**

intended to insure maximum benefits from the lake fishery. To protect spawning, drawdowns in excess of one-tenth foot per day during April and May were to be avoided. To insure suitable spawning areas (also served waterfowl), construction of at least one sub-impoundment was recommended. As upstream movement of anadromous species was already blocked by existing dams, the FWS recommended against construction of fish-passage facilities at the Clark Hill Dam. For reasons of safety and aesthetic improvement the FWS recommended that all timber be removed from the reservoir area to an elevation of five feet (1.5m) above the top of the maximum power pool. The control of domestic and industrial pollution was also recommended.

Fishery Resources -- Post-impoundment Occurrences

The FWS summarized the results of their several fishery-related preconstruction recommendations in their 1960 follow-up report (5). According to this summary, their recommendation to minimize spring drawdowns was being followed by the CE. The sub-impoundment initially suggested and subsequently determined by the FWS not to be justified, had not been constructed. As recommended, no fish ladder was constructed. An unexpected rise in water levels hindered timber clearing so that considerable timber was left standing in the reservoir contrary to FWS recommendations. Pollution had not proven to be a problem. The only FWS recommendation which produced any real benefits for the Clark Hill fishery was the one regarding spring drawdown.

Additional features of the project which have benefited fishermen in-

clude the construction by the CE of fish attractors in the reservoir and a fishing pier along the tailrace. Interestingly, neither feature was recommended by the FWS.

Fishery management activities of several types have been carried out at Clark Hill Lake. The introduction of exotic species has constituted one of the major management tools utilized at the project and nine species have been stocked over the years. A summary of the fish introduction data as provided by the Georgia GFD and the South Carolina WMRD is shown in Table 9. Georgia's stocking records for sauger were compiled from mimeographed materials from Departmental records (Don Johnson, pers. comm., 1976), while all other plants were described in various Dingell-Johnson reports (18,19,20,21).

The stocking records show that a number of cool and cold-water fish species have been introduced over the years. These plants were made after Hartwell Lake was constructed on the Savannah River, upstream from Clark Hill Lake. Limnological studies indicated that cold-water releases from Hartwell Lake provided a sufficient quantity of oxygenated, cold water in Clark Hill to support trout, walleye, and sauger. Georgia biologists have introduced such species as eastern brook trout, rainbow trout, and sauger, while South Carolina's stocking program has emphasized introduction of striped bass and the striped bass x white bass hybrid.

Biologists from the Georgia GFD and the South Carolina WMRD, in cooperation with the CE staff, have collected cove rotenone samples at Clark Hill Lake since it was first impounded in order to monitor the Clark Hill

Table 9. — Stocking records for exotic fish species planted in Clark Hill Lake and tailrace.

| Species | Number planted | Size planted | Year planted | Originating state |
|---|---|---|---|---|
| Brook trout | 30,000 | Adults | 1966 | Georgia |
| Hybrid (striped bass x white bass) | 3,260,000 | Fry | 1967 | S. Carolina |
| | 2,910,000 | Fry | 1968 | S. Carolina |
| | 5,000 | Fingerlings | 1968 | S. Carolina |
| | 6,970,000 | Fry | 1969 | S. Carolina |
| | 5,320,000 | Fry | 1970 | S. Carolina |
| | 12,640,000 | Fry | 1971 | S. Carolina |
| | 5,000 | Fingerlings | 1971 | S. Carolina |
| | 4,500,000 | Fry | 1972 | S. Carolina |
| | 1,100 | Fingerlings | 1972 | S. Carolina |
| | 4,500,000 | Fry | 1973 | S. Carolina |
| | 28,000 | Fingerlings | 1973 | S. Carolina |
| | 102,402 | Fingerlings | 1974 | S. Carolina |
| | 2,500,000 | Fry | 1975 | S. Carolina |
| | 224,000 | Fingerlings | 1975 | S. Carolina |
| Rainbow trout | 100[1] | Adults | 1960 | S. Carolina |
| | 15,000 | Adults | 1966 | Georgia |
| | 25,000 | Adults | 1967 | Georgia |
| Sauger | 395 | Adults | 1960 | Georgia |
| | 484 | Adults | 1964 | Georgia |
| Striped bass | 5,187[2] | Fingerlings | 1958 | S. Carolina |
| | 526 | Adults | 1959 | S. Carolina |
| | 50 | Adults | 1961 | S. Carolina |
| | 125,000 | Fry | 1963 | S. Carolina |
| | 16,500 | Fingerlings | 1975 | S. Carolina |
| Threadfin shad | 1,000 | Adults | 1957 | Georgia |
| | 2,000 | Adults | 1958 | Georgia |
| Walleye | 567 | Adults | 1962 | S. Carolina |
| White bass | 600 | Adults | 1957 | Georgia |
| | 765 | Adults | 1958 | Georgia |

1. Planted in the Clark Hill tailrace.
2. Later determined to be mostly white bass.

Lake fish community. While cove rotenone sampling inadequately quantifies standing crops of all fish species, major fluctuations in fish populations which are normally associated with littoral habitat (such as largemouth bass, bluegill, and other sunfishes) are commonly reflected in samples of this type.

Georgia's cove rotenone data included 10 years' information collected during the period 1954 to 1967. The Georgia data, gathered from several coves of variable sizes, were reported on an annual basis (18-20, 22-28). Table 10 summarizes information from the most consistently sampled site -- i.e., the spring or early summer samples from a shallow, one-acre cove in Cliatts Creek area of Georgia's Little River arm of Clark Hill Lake. The South Carolina data presented were gathered in August, 1958, from a one-acre cove in the Little River arm of that state (29).

Twenty-two species, in addition to members of the minnow group, have been recovered from the rotenone samples collected at Clark Hill Lake (Table 10). The samples reflected a typical warmwater fish community with largemouth bass, bluegill and crappie dominating the game fish component, while gizzard shad, threadfin shad and carp comprised the greatest share of the non-game fish community.

The total average standing crop was 156.6 kg/ha (139.7 lbs/ac). Largemouth bass, bluegill and crappie, collectively comprised 35.2 percent of the weight of fish collected in the rotenone samples. The three dominant non-game species comprised 51.3 percent by weight of the average sample. Yellow perch made up slightly less than 3 percent by weight of the aver-

Table 10. — Clark Hill Lake cove sampling results from Cliatts Creek, Little River arm (Ga) and Little River arm (S.C.) for the period 1954 to 1968

| Species | 1954 | | 1955 | | 1956 | | 1958 | | 1959 | | 1961 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Weight (kg/ha) | Percent of sample | Weight (kg/ha) | Percent of sample | Weight (kg/ha) | Percent of sample | Weight (kg/ha) | Percent of sample | Weight (kg/ha) | Percent of sample | Weight (kg/ha) | Percent of sample |
| Largemouth bass | - | 2.4 | 13.0 | 4.6 | 10.0 | 2.8 | 3.8 | 2.8 | 12.9 | 8.5 | 17.4 | 14.0 |
| Chain pickerel | - | 0 | 0 | 0 | 0 | 0 | T | T | 0.3 | 0.3 | 0 | 0 |
| White bass | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.1 |
| Yellow perch | - | 3.1 | 2.5 | 0.9 | 32.6 | 9.0 | 2.0 | 1.5 | 7.5 | 5.0 | 1.6 | 1.3 |
| Black crappie | - | 2.7 | 1.3 | 0.5 | 34.0 | 9.4 | 9.9[3] | 7.4[3] | 9.1[3] | 6.0[3] | 7.8 | 6.3 |
| White crappie | - | 0 | 0 | 0 | 0 | 0 | | | | | 6.3 | 5.1 |
| Bluegill | - | 14.0 | 31.2 | 11.1 | 70.8 | 19.5 | 42.5 | 31.8 | 59.2 | 39.1 | 23.9 | 19.3 |
| Redear sunfish | - | | | | 2.7 | 0.8 | 0.3 | 0.3 | 0.3 | 0.3 | 0 | 0 |
| Redbreast sunfish | - | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0.2 | 0.2 |
| Green sunfish | - | 6.2[4] | 3.3[4] | 1.2[4] | 0 | 0 | 0.1 | 0.1 | T | T | 0.8 | 0.6 |
| Warmouth | - | | | | 0.2 | T | 2.0 | 1.5 | 5.5 | 3.6 | 4.2 | 3.3 |
| Pumpkinseed | - | | | | 0 | 0 | 0 | 0 | 0.2 | 0.1 | 0.2 | 0.2 |
| Brown bullhead | - | 1.4[5] | 13.3[5] | 4.7[5] | 0.1[5] | T[5] | 0 | 0 | 0.7[5] | 0.4[5] | T | T |
| Flat bullhead | - | | | | | | 0.5 | 0.4 | | | 2.2 | 1.8 |
| Channel catfish | - | 3.7 | 2.5 | 0.9 | 0 | 0 | 0.3 | 0.3 | 1.6 | 1.0 | 0.5 | 0.4 |
| White catfish | - | 0 | 0 | 0 | 0.4 | 0.1 | 0 | 0 | 0 | 0 | 2.0 | 1.6 |
| Madtoms | - | 0.2 | 0.2 | T | 0 | 0 | T | T | T | T | 0.4 | 0.4 |
| Gizzard shad | - | 58.6 | 199.1 | 70.7 | 184.3 | 50.8 | 55.0 | 41.2 | 42.5 | 28.0 | 12.8 | 10.3 |
| Threadfin shad | - | 0 | 0 | 0 | 0 | 0 | 14.8 | 11.1 | 11.1 | 7.3 | 0.3 | 0.3 |
| Carp | - | 1.9 | 6.3 | 2.2 | 27.6 | 7.6 | 1.9 | 1.4 | 0 | 0 | 42.8 | 34.5 |
| Spotted sucker | - | 5.5 | 8.4 | 3.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.2 | 0.2 |
| River carpsucker | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Miscellaneous minnows | - | 0.3 | 0.5 | 0.2 | 0.1 | T | 0.2 | 0.2 | 0.5 | 0.4 | 0.1 | 0.1 |
| Total | - | 100 | 281.6 | 100 | 362.8 | 100 | 133.3 | 100 | 151.4 | 100 | 123.8 | 100 |

Table 10. — *(Continued)*

| Species | 1963 | | 1964 | | 1966 | | 1967 | | 1968[1] | | Mean[2] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Weight (kg/ha) | Percent of sample | Weight (kg/ha) | Percent of sample | Weight (kg/ha) | Percent of sample | Weight (kg/ha) | Percent of sample | Weight (kg/ha) | Percent of sample | Weight (kg/ha) | Percent of sample |
| Largemouth bass | 3.7 | 5.2 | 7.8 | 7.5 | 12.3 | 11.7 | 6.5 | 10.4 | 10.4 | 5.8 | 9.8 | 6.2 |
| Chain pickerel | 0.4 | 0.6 | 0.9 | 0.9 | 0 | 0 | 0.3 | 0.5 | 0 | 0 | 0.2 | 0.1 |
| White bass | 0.9 | 1.2 | 0.6 | 0.6 | 0 | 0 | 0 | 0 | 0 | 0 | 0.2 | 0.1 |
| Yellow perch | 0.3 | 0.4 | 1.9 | 1.9 | 1.3 | 1.3 | 0.9 | 1.4 | 5.6 | 3.1 | 5.6 | 3.6 |
| Black crappie | 6.4 | 8.9 | 1.8 | 1.7 | 2.2 | 2.1 | 0.4 | 0.7 | 0.7 | 0.4 | 6.8 | 4.3 |
| White crappie | 6.1 | 8.4 | 1.8 | 1.7 | 2.9 | 2.8 | 0.3 | 0.5 | 1.1 | 0.6 | 2.3 | 1.5 |
| Bluegill | 13.4 | 18.8 | 16.0 | 15.3 | 30.8 | 29.2 | 17.9 | 28.6 | 57.1 | 31.7 | 36.3 | 23.2 |
| Redear sunfish | 0 | 0 | 0.2 | 0.2 | T | T | 0.2 | 0.4 | 0 | 0 | 0.4 | 0.3 |
| Redbreast sunfish | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.3 | 0.3 | 0.5 | 0.1 | T | 0.1 | 0.1 |
| Green sunfish | 0.7 | 0.8 | 1.0 | 1.1 | 1.2 | 1.2 | 0.4 | 0.7 | 2.4 | 1.3 | 0.7 | 0.4 |
| Warmouth | 3.5 | 4.8 | 3.1 | 3.0 | 2.8 | 2.7 | 2.2 | 3.6 | 3.5 | 1.9 | 3.0 | 1.9 |
| Pumpkinseed | 0.2 | 0.3 | 0.3 | 0.3 | 0.2 | 0.2 | 0.4 | 0.7 | 0.4 | 0.3 | 0.2 | 0.1 |
| Brown bullhead | 0 | 0 | 1.0 | 1.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.1 |
| Flat bullhead | 0.7 | 0.8 | 0 | 0 | 0.3 | 0.3 | 0.4 | 0.7 | 2.7 | 1.5 | 1.0 | 0.6 |
| Channel catfish | 0 | 0 | 0 | 0 | 0.8 | 0.7 | 0.2 | 0.4 | 0 | 0 | 0.6 | 0.4 |
| White catfish | 10.5 | 14.7 | 7.0 | 6.6 | 0.9 | 0.8 | 4.4 | 7.0 | 17.0 | 9.5 | 4.2 | 2.7 |
| Madtoms | 0.1 | 0.1 | 0.2 | 0.2 | 0.1 | 0.1 | 0 | 0 | T | T | 0.1 | 0.1 |
| Gizzard shad | 16.4 | 22.8 | 28.6 | 27.4 | 30.0 | 28.4 | 7.7 | 12.3 | 33.0 | 18.3 | 60.9 | 38.9 |
| Threadfin shad | 0.3 | 0.4 | 0.2 | 0.2 | 10.8 | 10.2 | 1.9 | 3.0 | 10.1 | 5.6 | 5.0 | 3.2 |
| Carp | 8.0 | 11.1 | 12.1 | 11.6 | 0 | 0 | 11.3 | 18.0 | 33.6 | 18.7 | 14.4 | 9.2 |
| Spotted sucker | 0.2 | 0.3 | 19.3 | 18.4 | 8.3 | 7.9 | 6.5 | 10.4 | 0 | 0 | 4.3 | 2.7 |
| River carpsucker | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.3 | 0.7 | 0.1 | 0.1 |
| Miscellaneous minnow | 0.2 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | 0.2 | 1.1 | 0.6 | 0.3 | 0.2 |
| Total | 71.1 | 100 | 104.2 | 100 | 105.3 | 100 | 62.3 | 100 | 180.1 | 100 | 156.6 | 100 |

age sample. All other species, combined, contributed the remaining 10 percent.

An evaluation of the samples over time show that bass and bluegill, while fluctuating from year to year reflected no consistent increasing or decreasing trends in abundance over the 11-year period of record. As the lake matured, other species were observed in the samples, e.g., chain pickerel and threadfin shad in 1958, pumpkinseed sunfish in 1959, and white bass and redbreast sunfish in 1961. Threadfin shad and white bass were introduced into Clark Hill Lake in 1957.

Routine gill net sampling has been used in the last few years to monitor the survival, growth and condition of the striped bass and the striped bass x white bass hybrids that had been introduced in Clark Hill Lake. The mid-winter netting has successfully captured these exotic fishes at a rate averaging around 13 fish per 1,000 $m^2$ of net set overnight (21, 30,31).

Creel surveys of varying intensities and scope have been carried out at Clark Hill Lake during 14 seasons between 1955 and 1972. The Georgia GFD staff conducted the earlier work through 1968 and the South Carolina WMRD continued the effort through June 30, 1972. Harvest and angler success statistics for the Georgia studies are presented in Table 11.

The first six years of the Georgia creel surveys (1956 to 1963) resulted in an average angling effort estimate of 103,831 trips (424,288 hours) per year. Unfortunately, the last four Georgia surveys (1964 to 1968)

Table 11. — Summary of creel survey data provided by Georgia GFD for Clark Hill Lake

| | 1955[1] | 1956 | 1957 | 1958 | 1959 | 1961 | 1963 | 1964[2] | 1966[2] | 1967[2] | 1968[2] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Effort** | | | | | | | | | | | |
| Total trips | 51,970 | 105,200 | 155,880 | 82,330 | 97,433 | 107,793 | 74,351 | 33,309 | 26,228 | 55,089 | 44,838 |
| Trips/ha (A) | 1.8 (0.7) | 3.7 (1.5) | 5.5 (2.2) | 2.9 (1.2) | 3.4 (1.4) | 3.8 (1.5) | 2.6 (1.1) | - | - | - | - |
| Total hours | 244,259 | 420,800 | 452,052 | 367,192 | 431,628 | 533,577 | 340,480 | 164,880 | 110,424 | 231,376 | 190,560 |
| Hours/ha (A) | 8.6 (3.5) | 14.9 (6.0) | 16.0 (6.5) | 13.0 (5.3) | 15.2 (6.2) | 18.8 (7.6) | 12.0 (4.9) | - | - | - | - |
| **Harvest** | | | | | | | | | | | |
| Total number | 64,443 | 145,176 | 216,673 | 128,150 | 224,876 | 361,809 | 316,561 | 187,794 | 159,449 | 399,583 | 307,561 |
| Number/ha (A) | 2.3 (0.9) | 5.1 (2.1) | 7.6 (3.1) | 4.5 (1.8) | 7.9 (3.2) | 12.8 (5.2) | 11.2 (4.5) | - | - | - | - |
| Total kg | 31,352 | 65,851 | 132,220 | - | - | - | - | - | - | - | - |
| Total lbs | 69,120 | 145,176 | 291,495 | - | - | - | - | - | - | - | - |
| Kg/ha (lbs/A) | 1.1 (0.5) | 2.3 (0.9) | 4.7 (1.9) | - | - | - | - | - | - | - | - |
| **Success** | | | | | | | | | | | |
| Number/hr | 0.26 | 0.34 | 0.48 | 0.35 | 0.52 | 0.68 | 0.93 | 1.14 | 1.44 | 1.73 | 1.61 |
| Kg/hr (lbs/hr) | 0.13 (0.28) | 0.16 (0.35) | 0.29 (0.64) | - | - | - | - | - | - | - | - |

[1]Bank fishing underestimated.
[2]Figures represent Savannah River Section only. In 1963, 47% of the total effort and 44% of the harvest occurred in the Savannah River Section.

covered only the Savannah River arm of the reservoir. During Georgia's final survey covering the entire lake (conducted in 1963), approximately 47 percent of the total angling effort was received by the Savannah River arm. Therefore, for this report, an angling effort estimate for the entire reservoir for the 1964 to 1968 period was obtained by doubling (approximately) the Savannah River arm statistics for those years. This manipulation of the data indicated a total angling effort on the lake of approximately 84,821 trips (370,872 hours) per year. The average annual angling effort for all 10 Georgia surveys was approximately 96,227 trips (402,922 hours). Computed for a 28,329 ha (70,000 ac) average pool, the angling intensity was estimated to be 3.4 trips/ha (1.4 trips/ac).

One complete year (1971) and two half-years (1970 and 1972) creel data were available from South Carolina (Table 12). The average estimated annual angling pressure from these surveys was 850,070 hours per year. No estimate of the estimated number of angler-days was provided. Applying the average length of trip from the Georgia studies (4.2 hours) to South Carolina's angler-hours statistic, provided an average annual visitation during the 1970-1972 period of 202,400 trips. This slightly exceeds the average effort (2.1 x) estimated from the Georgia GFD data for the period 1956 to 1968.

The South Carolina surveys may more precisely reflect angler utilization of Clark Hill Lake than the Georgia studies. It should be noted that South Carolina's creel studies were more current, more intensive, and were designed by the Statistical Department at North Carolina State Uni-

Table 12. — Summary of creel survey data provided by South Carolina WMRD for Clark Hill Lake[1]

| | 1970[2] | 1971 | 1972[3] |
|---|---|---|---|
| **Effort** | | | |
| Total trips | - | - | - |
| Trips/ha (A) | - | - | - |
| Total hours | 302,311 | 915,786 | 482,043 |
| Hours/ha (A) | 10.7 (4.3) | 32.3 (13.1) | 11.0 (6.9) |
| **Harvest** | | | |
| Total number | 207,170 | 1,375,105 | 749,005 |
| Number/ha (A) | 7.3 (3.0) | 48.5 (19.6) | 26.4 (10.7) |
| Total kg | 78,692 | 460,488 | 190,967 |
| Total lbs | 173,487 | 1,015,200 | 421,011 |
| Kg/ha (lbs/A) | 2.8 (2.5) | 16.3 (14.5) | 6.7 (6.0) |
| **Success** | | | |
| Number/hr | 0.69 | 1.50 | 1.55 |
| Kg/hr (lbs/hr) | 0.26 (0.57) | 0.50 (1.11) | 0.40 (0.87) |

[1]Statistics recomputed for 28,329 ha (70,000 A) rather than 31,769 ha (78,500 A) as presented.

[2]Data represents only later one-half of 1970 (July 1 through December 31).

[3]Data represents only first one-half of 1972 (January 1 through June 30).

versity.

Angler use estimates were also developed by the CE. Their figures are derived from a system of traffic counters established at entrances to various access points. In 1971, the CE reported 4,582,000 user-days for the Clark Hill Lake project. The proportion of this activity composed of fishing was estimated at 28 percent. Thus, the CE estimate of angling use of Clark Hill Lake in 1971 was 1,283,000 angler-days. This was approximately six times greater than the South Carolina WMRD estimate for the same year.

The sport fish harvest statistics from the South Carolina surveys (Table 13) indicated that the recreational fishery was dominated numerically by crappie, with largemouth bass second in contribution. By weight, the relative ranking of these two species was reversed, with largemouth bass first and crappie second. White bass was the third most important contributor to the sport harvest by number and weight caught.

The harvest of such fish as striped bass, striped bass x white bass hybrids, and rainbow trout was of special interest. Except for 1971, the contribution of these fish was negligible. In combination, the three species contributed only 1.1 percent to the harvest in 1971. An accelerated stocking program with the hybrid since 1972 probably increased the contribution of this fish in years subsequent to the creel surveys.

During March and April of 1974 and 1975, a creel survey was undertaken of the Clark Hill tailrace (30, 31). Anglers spent an average of 10,362

Table 13. — Recreational harvest of fish from Clark Hill Lake for the period July 1, 1970, through June 30, 1972

| Species | Harvest | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1970[1] | | | 1971 | | | 1972[2] | | |
| | Number | Weight kg | Weight (lbs) | Number | Weight kg | Weight (lbs) | Number | Weight kg | Weight (lbs) |
| Largemouth bass | 51,921 | 32,118 | (70,809) | 144,169 | 123,091 | (271,370) | 110,581 | 87,690 | (193,323) |
| Bluegill | 4,227 | 671 | (1,479) | 25,479 | 3,287 | (7,246) | 233,630 | 37,391 | (82,432) |
| Crappie | 135,594 | 38,096 | (83,987) | 900,176 | 143,322 | (315,970) | 364,815 | 50,358 | (111,020) |
| White bass | 3,900 | 2,329 | (5,135) | 248,724 | 161,109 | (355,185) | 31,413 | 12,831 | (28,287) |
| Striped bass | 0 | 0 | (0) | 0 | 0 | (0) | 0 | 0 | (0) |
| Hybrid | 0 | 0 | (0) | 13,965 | 9,055 | (19,962) | 0 | 0 | (0) |
| Catfishes | 11,528 | 5,478 | (12,077) | 41,403 | 20,516 | (45,229) | 7,221 | 2,598 | (5,727) |
| Walleye | 0 | 0 | (0) | 0 | 0 | (0) | 926 | 63 | (138) |
| Rainbow trout | 0 | 0 | (0) | 1,189 | 108 | (238) | 419 | 38 | (84) |
| Totals | 207,170 | 78,692 | (173,487) | 1,375,105 | 460,488 | (1,015,200) | 749,005 | 190,967 | (421,011) |

[1]Data represents only later one-half of 1970 (July 1 through December 31).
[2]Data represents only first one-half of 1972 (January 1 through June 30).

angler hours per two-month period and harvested 24,668 fish. The average catch rate was 2.4 fish per hour with the majority of the harvest composed of crappie, yellow perch, white bass, bluegill, and hybrids (in descending order of importance). The CE has constructed a fishing platform to facilitate bank fishing in the Clark Hill tailrace (32).

Fisheries Resources -- Evaluation of Planning Input

Although several recommendations were provided by the FWS to maximize the fishery benefits of the Clark Hill Lake project, few appear to have been viable planning measures by today's standards. Consistent with today's accepted management concepts was the recommendation to minimize water level fluctuations during the spring spawning season. This recommendation has been accepted by the CE, and lake operations seek to restrict water-level fluctuations to the greatest degree possible during the spring spawning season.

The recommendation to control domestic and industrial pollution was certainly proper with respect to the aquatic community. Whether the CE could properly be expected to control pollution sources beyond project boundaries seems questionable for the time. The recommendation by the FWS not to construct a fish ladder probably had little bearing one way or another on the construction agency as such an action was not considered by the CE. The FWS did not include a caveat which related to the laddering or removal of downstream dams. The FWS recommendations to clear all timber from the reservoir basin and to construct a sub-impoundment for spawning purposes for bass and other sunfishes, are questionable by current fish man-

agement standards.

The FWS predicted a significant long-term improvement in the sport fishery of the project area as a result of Clark Hill project construction, although the reservoir was expected to be turbid for a considerable part of the year due to heavy silt load in the Savannah River. This condition was expected to be ameliorated by the construction of other lake projects above Clark Hill on the Savannah River. Although these unique conditions at the Clark Hill Lake project were mentioned in the report, the FWS did not further consider them in developing resource projections. Use and harvest projections for Clark Hill Lake were determined simply by reading directly from the von Limbach predictive curve employed by the FWS at the time. By this means, total annual monetary values to be expected from average reservoir fisheries were plotted against surface area of the impoundment. The graph-derived figure for Clark Hill Lake was $180,000. No modifications of this "average" value were made to reflect either local considerations or changes expected over time, such as the upstream construction which was expected to improve the water quality of Clark Hill Reservoir. This failure to consider local conditions deviated from prescribed planning procedures. The von Limbach Curve should have been used only as a general guide. Local conditions peculiar to the project should have been used to modify the basic ralationships as identified from the curve.

The monetary values of the von Limbach Curve reflected the average expenditures by sportsmen to harvest a pound of fish. Different species of

fish were arbitrarily assigned different monetary values ranging from $3.00 to harvest a pound of trout to 75¢ per pound of sunfishes and catfishes. Largemouth bass were assigned an intermediate value of $2.00 per pound. In this instance, a total annual value of $180,000 was assigned to Clark Hill (assumed 78,000 surface acres), some $2.30 per acre. Although this total value was not associated in the 1946 report with specific quantities of individual species, it is evident that this value would have represented a maximum sport harvest of 3 pounds/acre (3.4 kg/ha). This estimated 3-pound/acre harvest figure was computed by dividing the value per acre ($2.30) by the value of the least valuable species harvested ($0.75 per pound for catfish or sunfish).

The most precise survey which estimated the Clark Hill sport fish harvest by weight was the 1971 creel conducted by the South Carolina WMRD. This survey produced an estimated harvest figure of 14.5 lbs/acre. This value is approximately 5 times greater than the highest possible harvest (3 lbs/acre) assumable under the pre-construction projection.

Little firm evidence is available to reflect the impact of Clark Hill Lake on the downstream fishery. The turbidity problem, characteristic of pre-impoundment conditions, was undoubtedly alleviated. Recent creel studies of the tailrace area indicate excellent fishing, at least seasonally, in the Clark Hill tailrace; reported success rate is 2.4 fish harvested per angler hour.

## SUMMARY

The Clark Hill Lake project, located on the Savannah River between Georgia and South Carolina, was one of only two CE constructed water development projects in the South Atlantic Division that were found to have sufficient pre-impoundment and post-impoundment information available to permit an evaluation of the fish and wildlife planning procedures. The project was authorized for power, flood control, and navigational purposes in 1944, and completed in 1953. The construction agency received planning input from the FWS in 1946. Thus, evaluation of fish and wildlife resources at the Clark Hill project represented an opportunity to study the FWS's planning procedures during a very early period in the program's existence.

The record of fish and wildlife planning for the Clark Hill Lake project shows that cooperation between the concerned agencies was poor, priorities for state input were low, and overall fish and wildlife planning was inadequate and ineffectual. The 1946 FWS planning report was based on engineering data which were subsequently modified by the CE. Despite the changes and clarifications presented, no corrected quantitative projections or impact predictions were provided by the FWS. It appeared that the FWS had developed the attitude that, having failed to influence the construction agency with their prior testimony, there was little to be gained by preparing detailed, updated projections at a later date.

An unusually large acreage above the zone of inundation was purchased by the construction agency. This publicly owned property had great impact

upon the area's terrestrial wildlife resources. Perhaps the Service's greatest contribution to the fish and wildlife resources at the Clark Hill Lake project was that the agency expressed an early interest in development of a national wildlife refuge on a portion of this incidentally acquired wildlife habitat. Although the Services' request for the refuge was subsequently withdrawn, the refuge-related discussions may have set the stage for the states' subsequent successful request for zoning and licensing of some of the same areas for fish and wildlife purposes.

At any rate, approximately 25,500 ha (63,010 ac) of terrain surrounding the 28,330 ha (70,000 ac) normal pool are open to public hunting, including 13,383 ha (33,070 ac) under license to the Georgia GFD and the South Carolina WMRD.

The accuracy of specific resource-related predictions, for which post-impoundment data of comparable scope permit evaluation, generally proved to be poor. Since forest and farm game projections contained in the 1946 report related only to the total losses expected within the zone of permanent inundation, there were few quantitative projections available for the peripheral project lands and thus for post-impoundment comparative evaluation. In other words, the basic information provided to the construction agency was that no upland game would be supported by the lake. An estimated 14,930 hunter-days are supported by the upland game community on the Clark Hill project lands which were not addressed either in the 1946 planning report or subsequently.

Since the 1946 FWS report for Clark Hill was prepared, many small farms have reverted to forest habitat over much of the southeast, including the immediate project area. This increase in forest habitat was not anticipated by the FWS personnel and the future of deer and turkey on project lands was not even addressed. Current estimates of the big game resources on Clark Hill project land open to public hunting are 3,140 deer and 735 turkeys. Big game hunting on project lands was estimated for this evaluation at around 9,450 hunter-days for deer and 860 hunter-days for turkey.

The value of the waterfowl resource was expected to be increased by approximately nine-fold as a result of project construction. The procedure employed by the fish and wildlife agencies to generate this prediction was never uncovered. Prior to project construction, an estimated 125 to 500 geese used the Savannah River during the migratory season. The management agencies have never subsequently surveyed the migratory waterfowl use of Clark Hill Lake. Waterfowl hunting pressure on the Lake was estimated for purposes of this evaluation to be 2,020 hunter-days annually.

Little data were available regarding furbearers. Some 11 species were attributed to the project area. Expansion of the beaver population has indirectly benefited waterfowl by creation of wetland habitat.

The Savannah River contained heavy silt loads prior to construction of Clark Hill Lake and the fishery was judged poor. The warmwater fish community included blue catfish, bluegill, redbreast sunfish, crappie,

largemouth bass, longnose gar and carp.

Construction of the reservoir was expected to significantly improve fishing opportunities in the project area. To maximize fishery benefits, several recommendations were submitted to the construction agency including some that would not be considered valid by modern fish management standards.

The reservoir fishery, evaluated by means of the von Limbach Curve, was assigned an annual value of $180,000. Considering the value structure upon which the von Limbach Curve was developed, the $180,000 valuation could have represented a maximum sport fish harvest of 3.4 kg/ha. Reflecting the gross inadequacy of that early valuation method, the most recent creel survey of Clark Hill Lake (1971) produced a harvest estimate of 16.3 kg/ha, roughly five times greater than the maximum deemed possible in 1946.

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