TECHNICAL REPORT Y-76-2

DATA EVALUATIONS AND RECOMMENDATIONS
FOR COMPREHENSIVE PLANNING FOR THE
YAZOO RIVER BASIN, MISSISSIPPI

Volume II

by
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Errata Sheet

No. 1

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Volumes I and II
Technical Report Y-76-2
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1. Credit for Figures 7, 8, and 9 should have been given to R. L. Shelton and E. E. Hardy in their publication "Design Concepts for Land Use and Natural Resource Inventories and Information System," April 1974, Resource Information Laboratory, Department of Natural Resources, Cornell University, Ithaca, New York.

2. On page F16, Volume II, line 20, 9.2 percent should be 0.92 percent.
PREFACE

The study reported herein, sponsored by the U. S. Army Engineer District, Vicksburg (VXD), was conducted to evaluate environmental data requirements and needs for the comprehensive planning of water and related land resources of the Yazoo River Basin, Mississippi. Information collected during this evaluation was to serve as a reference source and to provide guidance to VXD in its preparation of a plan of study for the development and assessment of alternative solutions during its plan formulation phase.

The study was conducted from July 1975 to February 1976 by an interdisciplinary team at the U. S. Army Engineer Waterways Experiment Station (WES). The study was authorized by COL Gerald Galloway, District Engineer, VXD. VXD provided valuable support to the study, especially through Messrs. Kerry Pitts and Ron Miller, the principal contacts.

This report was prepared by personnel of the Environmental Effects Laboratory (EEL), WES, with help by individual WES contractors and consultants. The study was under the direction of Dr. Thomas J. Wood, former Chief, and Dr. Walter B. Gallaher, Chief, Natural Resources Development Branch, EEL, and under the general supervision of Dr. Conrad J. Kirby, Chief, Environmental Resources Division, and Dr. John Harrison, Chief, EEL. The study leader and principal author of this report was Dr. Frank W. Suggitt, Consultant to the Environmental Resources Division.

A special acknowledgement is given to the following individuals who performed a critical review of the contents of this report: Mr. Don Robey of the Ecosystem Research and Simulation Division, EEL; Mr. Ed Link of the Mobility and Environmental Systems Laboratory, WES; Mr. John Shamberger of the Soils and Pavements Laboratory, WES; Messrs. James Foster and Randy Oswalt of the Hydraulics Laboratory, WES; and Messrs. Bill Hobgood, Kerry Pitts, Roy Smith, and Rogers Turner, VXD.

Information provided in Volume II of this report represents a detailed description of environmental conditions, data requirements, and recognized needs for the comprehensive planning of water and related
land resources of the Yazoo Basin. The environmental conditions are subdivided into the following components and presented accordingly:

Appendix B--Geology and Physiography of the Yazoo Basin, Charles R. Kolb, Ph. D., Geologist.

Appendix C--Physical and Chemical Characteristics of the Yazoo Basin, Charles R. Bingham, Limnologist.

Appendix D--Aquatic Resources of the Yazoo Basin, Billy K. Colbert, Aquatic Ecologist.

Appendix E--Terrestrial Resources of the Yazoo Basin, Ellis J. Clairain, Jr., Forester, Fishery Biologist; Jonathan R. Clark, Wildlife Scientist; Elray Nixon, Ph. D., Botanist.

Appendix F--Sociocultural Resources of the Yazoo Basin, Sue Ellen Richardson, Sociologist; Frank W. Suggitt, Doctor of Public Administration, Recreation and Water Resource Specialist.

COL G. H. Hilt, CE, and COL J. L. Cannon, CE, were Directors of WES during the conduct of the studies and preparation and publication of this report. Mr. F. R. Brown was Technical Director.
APPENDIX B: GEOLOGY AND PHYSIOGRAPHY OF THE YAZOO BASIN
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Table B1

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U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

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Introduction

1. The drainage basin of the Yazoo River encompasses 13,355 square miles* bordered on the north by the drainage divides of the Wolf and Hatchie River basins, on the east and south by the divides of the Tombigbee and Big Black River basins, and on the west by the artificial levees that flank the Mississippi River. Major tributaries of the Yazoo are the Tallahatchie, Coldwater, and Yalobusha Rivers and the Big Sunflower-Steele Bayou system. Nearly the entire drainage enters the Mississippi at Vicksburg where a canal diverts the Yazoo flow into the eastern arm of an abandoned Mississippi River channel and through this arm to the Mississippi.

2. From the air, a plume of tannish-brown, sediment-laden water can be seen extending downstream from the confluence of the Yazoo and the Mississippi, the water of the Yazoo obviously the muddier of the two. Much of the sediment load in the Yazoo is due to erosion in the upland areas through which it flows, and there is evidence that the muddiness of the Yazoo has increased markedly since the advent of the early white settlers. The environmental implications are obvious, and scattered and fragmentary data on sediment loads in the Yazoo should be collected, analyzed, and assessed.

3. North Mississippi is customarily divided into six physiographic provinces; portions of five of these make up the Yazoo Basin. From the topographically higher northeastern portion of the Yazoo Basin to the Mississippi River on the west, these provinces are: (a) the Pontotoc Ridge; (b) the Flatwoods; (c) the North Central Hills; (d) the Loess Bluffs; and (e) the Mississippi Alluvial Plain, commonly called the Yazoo Delta (Figure B1).

4. The youngest materials forming the surface are within the Alluvial Plain and in the Loess Bluffs with ages ranging from 25,000 years to the present. In contrast, geologic formations ranging

* A table for converting U. S. customary units of measurement to metric (SI) units is found on page B3.
Figure B1. Physiographic regions of the Yazoo Basin
in age from late Cretaceous (100 million years) to middle Eocene (50 million years) form the surface in the Pontotoc Ridge, the Flatwoods, and the North Central Hills. In a few instances the constituents comprising these older formations, usually sand, silt, and clay, have become lithified into hard, durable rock. In more instances, a weakly lithified sandstone, siltstone, or limestone has resulted. In the vast majority of cases, however, these older geologic formations consist of soils, in the sense the samples can be crumbled between thumb and forefinger. The soils may be very dense, as befits material deposited such a long time ago; but they afford little resistance to the processes of oxidation and erosion. Residual soil areas may be weathered to depths as great as 20 ft or form only a surficial layer less than 1 ft thick. In a few instances, undisturbed, unweathered geologic strata reach the surface.

5. Erosion by large and small streams, slope wash, and similar alluvial processes has stripped the less dense and weaker soils from one area and deposited them on another. Thousands of tiny channels with narrow flat floodplains merge with larger downstream floodplains, and these in turn merge with floodplains underlain by thick alluvium along the major streams tributary to the Yazoo. Alluviated flats and floodplains in the upland areas are complexly interspersed with areas where only residual soils form the surface.

6. Despite this complexity, there is an inherent orderliness in the disposition of the landforms, the present surface soils, and the relief and general physiography that has resulted. And most of this order results from the disposition and nature of the underlying geologic formations.

7. The older geologic formations dip at fairly shallow angles toward the west and southwest so that the oldest materials lie in the northeast corner of the basin and successively younger soils form the surface as one approaches the Mississippi Valley. Figure B2 schematically illustrates the situation along a section from near New Albany to Greenville, or along the approximate axis of the Yazoo Basin. Cretaceous and Paleocene beds underlie the Pontotoc Ridge; Porters Creek
Figure B2. Principal geologic formations of the Yazoo Basin
clays underlie the Flatwood; and Midway, Wilcox, and Claiborne forma-
tions underlie the North Central Hills. Farther to the west, the older
geologic horizons are buried beneath a cover of Pleistocene loess under-
lain by sand and gravel or by the thick Holocene (Recent) deposits of
the Mississippi Alluvial Plain. The chart in Figure B2 names each forma-
tion that has been mapped, places it within the generally accepted
geologic framework, and identifies the physiographic province with
which it is associated.

8. In the following paragraphs, the major geologic formations
underlying each of the physiographic provinces are briefly described.
It should be understood that although a given geologic formation may
consist of a single lithologic type, e.g. a limestone, a chalk, or a
sand unit, it more often consists of several lithologic types deposited
in essentially the same time span. Thus the Ackerman formation consists
of a heterogeneous mixture of sand, silt, and clay units that changes
rapidly within short distances horizontally and vertically because the
Ackerman is essentially an old delta or a series of ancient deltas where
lithologies changed rapidly as streams shifted from one delta to another.
Marine beds, e.g. the Porters Creek clay, on the other hand, are often
characterized by similar lithologies over great distances. With this
in mind it is useful to consider the Cretaceous and Tertiary deposits
listed in Figure B2 in the following light: From the deposition of the
Ripley through the Porters Creek formations, the Yazoo Basin was an
area of marine deposition. Deposition of the Naheola through the Cock-
field formations, on the other hand, occurred largely in a deltaic
environment. Some marine and some continental beds occur, but rapid
changes in lithology should be expected. During Moodys Branch and Yazoo
Clay times, the area was again below sea level and marine deposition
prevailed. And finally, deposition during the Pleistocene and Recent
epochs was continental in nature having occurred at elevations well
above sea level.

Pontotoc Ridge

9. The three oldest geologic formations in the basin are, from
oldest to youngest, the Cretaceous Ripley and Prairie Bluff formations and the Paleocene Clayton formation. They form the physiographic province known as Pontotoc Ridge, a densely wooded area with pronounced relief. Highest elevations in the basin, on the order of 700 ft,* are found in this province.

10. Lithologically, the Ripley formation consists of about 200 ft of blue-black impure marl and dark laminated clays with many thin, scattered beds of yellow sand. Above this is the McNairy sand tongue, a cross-bedded micaceous marine sand with some sandstone beds. These durable sandstones form the highest hills in the Yazoo Basin. The upper part of the Ripley consists of about 150 ft of limestone, marl, and a few sandstone and sand layers. The unit thickens along the strike at the expense of the McNairy sand. The limestone is highly fossiliferous. Several classic fossil-collecting localities are found within the Ripley formation in the northeast corner of the Yazoo Basin.

11. The Prairie Bluff is a fossiliferous, blue-black and dark-gray, impure chalk that merges northward with the sandier Owl Creek formation. It is about 40 ft thick and at the surface weathers into a blue-gray, sticky calcareous clay that contrasts markedly with the red colors produced by weathering of the Ripley and the overlying Clayton beds. Marcasite and pyrite concretions, phosphatic nodules, and calcareous concretions and nodules are common.

12. The Clayton formation consists of a basal limestone and marl member and an upper marl, clay, and sand member. Its thickness in the northeast Yazoo Basin is about 60 ft. Ironstone concretions are common in the lower part of the Clayton, and concentrations of these concretions along specific horizons result in distinctive scarps. Weathered ironstone nodules are common on the surface. The upper marl member of the Clayton consists of dark laminated clays, thin sands, and some fossil-bearing marls.

13. The Pontotoc Ridge reflects the presence of the various strata

* All elevations cited herein are approximate elevations referred to mean sea level (msl).
underlying it, which, as a group, are more resistant to erosion than materials elsewhere in the Yazoo Basin. The series of ridges rises to conspicuous heights above the Flatwoods physiographic province to the west. Dips of the strata are on the order of 30 ft per mile.

**Flatwoods**

14. West of the Pontotoc Ridge is a conspicuously flat area that has been called the Flatwoods since 1860 or earlier. Elevations range from 300 to 400 ft. It is underlain by the Porters Creek clay, which offers little resistance to erosion and yields a heavy stiff soil that is difficult to cultivate. Dirt roads in the area are practically impassable in wet weather. Names such as Hell, Damnation, and Mud Creeks are undoubtedly the response of the early settlers who named them to the frustrations of cross-country movement. There are relatively few hills, and most of those that are present are erosional remnants of the overlying red Wilcox sand.

15. The Porters Creek is a dark-gray, montmorillonitic marine clay, which weathers to a sticky clay soil at the surface. Colors at the surface vary from red to gray. The unweathered Porters Creek is uniformly dark gray. It is about 300 ft thick in the northeast Yazoo Basin. Much of the unweathered material shows no stratification, but possesses a marked conchoidal fracture, causing it to break out into lumps from 1 to 4 in. in diameter. When the clay is cut with a knife, its texture is much like soap. Selenite and pyrite are commonly found throughout the formation. Of possible economic importance in the Porters Creek clay is a bauxite-kaolinite zone, which often lies directly on top of the Porters Creek clay and is believed to be the result of weathering during the long interval between the deposition of the Porters Creek and the overlying Wilcox strata.

**North Central Hills**

16. This physiographic province is characterized by thorough stream
dissection, moderate to gentle slopes, flats developed along streams from the mouths of the streams well up toward the heads, and terraces or second bottoms bordering the floodplains of the larger streams. The region as a whole is well drained by a complex of streams forming a dendritic pattern. Hills and ridge tops are well rounded, and lineations of hills and ridges follow the strikes of the less erodible of the underlying geologic formations. The contact between the Claiborne and Wilcox groups, for example, stands out as a series of disconnected ridges.

17. The uppermost formation in the Midway group, the Naheola, consists generally of laminated fine sand and thin layers of dark-gray to light-gray silty clay. Flattish concretions of iron oxide are common. Lignitic clays or shales tend to grade laterally into thin beds of lignite. Weathered surface soils commonly consist of fine-grained sand.

18. The Wilcox, where it underlies the Yazoo Basin, is divided into a lower Fearn Springs formation and an overlying Ackerman formation. The Wilcox is the most heterogeneous of the Tertiary groups of formations of Mississippi from the standpoint of lithology. Deposited in a deltaic environment, sand, silt, and clay are intricately intermingled; and changes in lithology occur over very short distances. One investigator writes, "No sand unit is free from silt or clay, or both; no body of silt is free from sand or clay, or both; and no aggregate of clay lacks its silt and fine sand component." The Fearn Springs and the Ackerman have similar lithologies, and their distinction in the field must often be based on stratigraphic evidence. Both can be described as consisting of sand, silt, clay, and iron ore, with colors varying from gray to greenish gray to white. Both are lignitic with the Ackerman being the more lignitic of the two. The sand in the Ackerman is sometimes coarse; sand in the Fearn Springs is invariably fine grained. Concretionary masses of iron carbonate and iron oxide are found in both formations. Siderite concretions are found principally in the Ackerman. The thickness of the Wilcox in the Yazoo Basin varies, but averages about 400 ft.

19. The clays of the Wilcox formations form red silty loam at the surface; the sands form fine silty micaceous soils, some of the poorest in the Yazoo Basin for agricultural purposes. The clays form low rolling
hills and ridges, whereas the sands form hills and ridges more rugged and of greater relief. Landslides are common in the Wilcox clays after long rainy spells along hillsides, road cuts, and gullies.

20. The Claiborne group consists of the Meridian, the Tallahatta, and the Kosciusko formations in the northern portion of the North Central Hills, in Marshall County, for example. To the south, in Yalobusha County, the Zilpha and Winona formations are recognized between the Tallahatta and the Kosciusko.

21. The Meridian formation consists principally of a coarse- to medium-grained sand of various colors. Some weakly indurated sandstone units are also found. The sand and sandstone of the Meridian form rugged hills and ridges of marked elevation, some ridges as much as 150 ft above the alluvial lowlands of the larger flanking streams. Some of the smaller streams form deep valleys. Surface soils are consistently sandy and permeable.

22. The Tallahatta formation consists of glauconitic sand and shale. On drying, the shale often splits into very thin flakes known as paper shale. Unlike the Tallahatta near the Alabama border, few indurated Tallahatta strata are found within the Yazoo Basin. Tallahatta buhrstone, which forms high rocky bluffs near the city of Meridian, for example, is not found in the Yazoo Basin. Topography on the Tallahatta in the Yazoo Basin consists principally of gently sloping hills and ridges. It weathers into a fine micaceous silty sand at the surface.

23. The Winona is principally fine- to medium-grained quartz sand with thin partings and flakes of clay. The Winona on weathering becomes an intense red. It is too thin in the Yazoo Basin (on the order of 25 ft thick) to have a distinctive topographic expression.

24. The Zilpha is composed of gray to light chocolate-brown silty sand and shale grading downward into a nearly pure, blocky, dark-gray clay. Like the underlying Winona, it is too thin, about 60 ft, to have a distinctive topographic expression; but it gives rise to a reddish-tan and light-gray silty soil at the surface that gullies easily.

25. The Kosciusko (Sparta) is a heterogeneous mixture of sand, ferruginous sandstone, and fragmented quartzite. It is about 200 ft
thick and forms cuestas with steep escarpments, especially where the hills and ridges are held up by sandstone. Where there is no sandstone, the topography is rolling and of less relief. The Kosciusko formation weathers to a fine silty loam that is very unfertile. In many places it has been abandoned for farm use, the productive upper few feet of soil having eroded away after a few decades of farming.

26. The Cook Mountain (Shipps Creek) consists of chocolate-brown to light-gray laminated carbonaceous shale with thin sand lenses and lignitic clays. Thin interbeds of impure lignite and fossil leaves occur sparingly throughout the formation. Lenses of quartzitic sandstone as well as siltstone and siderite concretions are common on outcrops. The thickness of the formation is estimated at 175 ft.

Loess Bluffs

27. A profound hiatus or gap in the age of the soils that form the surface in the Yazoo Basin occurs at the boundary between the Loess Bluffs and the North Central Hills. The youngest geologic strata exposed in the North Central Hills is of upper Claiborne age, estimated at about 40 million years (see Figure B2). The loess, on the other hand, is only 10,000 to 25,000 years old; while the oldest of the sand and gravel strata that underlie the loess is on the order of 1.5 million years. This age gap continues to the west beneath the Mississippi Alluvial Plain, where Holocene (Recent) materials overlie Tertiary sediments. The Holocene is never more than 15,000 years old. The age of the Yazoo clay beneath the Holocene of the Alluvial Plain is on the order of 35 million years. A heavy line in the geologic section in Figure B2 indicates this great gap in geologic time, a gap caused by erosion and/or lack of deposition.

28. The Loess Bluffs are formed of the most distinctive and homogeneous of the soils in the Yazoo Basin. They consist of tan to buff-colored silt that characteristically forms spectacular vertical bluffs. Under appropriate conditions these bluffs will retain their verticality for decades. The loess has long been described in the geologic
literature as being massive and essentially unstratified; however, close examination of loess exposures discloses faint banding and other features that resemble stratification. Microscopic examination and laboratory tests of loess reveal it to consist of more than 95 percent angular silt-size particles. The particles are stacked in random fashion resulting in a high-porosity material of low density. Calcareous clay binds the silt particles together. As long as this calcareous cement is effective, the material will stand vertically. Wetting quickly breaks down this bond between the particles, however; when this occurs, the silt loses strength and quickly fails. As a result, dissection by running water has carved the loess into some of the most intricate relief found within the Yazoo Basin. On aerial photographs the Loess Bluffs stand out as a labyrinth of complexly disposed ridges and valleys with relief, i.e. change in elevation per unit distance, equal to or greater than any other soil region in the United States.

29. There is some controversy concerning loess origin; however, the vast majority of geologists who have worked in loessial areas believe it to be windblown. Moreover, they have been able to associate loess deposition with the advance and retreat of the ice sheets during the Pleistocene or Ice Age.

30. The Pleistocene epoch began some 2 million years ago. For reasons as yet unknown, world climates began to cool significantly toward the end of the Pliocene and the beginning of the Pleistocene. The Greenland ice sheet extended southward and westward and coalesced with massive sheets of ice building in northern Canada. Concurrently ice sheets in northern Europe and Siberia advanced southward. In early Pleistocene times, massive sheets of continental ice, 1 or 2 miles thick, girdled the northern hemisphere and moved inexorably southward. At least five times these continental ice sheets advanced and retreated across the northern hemisphere, scouring vast quantities of material and radically altering the drainage patterns of major rivers that flowed northward toward the arctic regions.

31. The effect of the Ice Age on the Lower Mississippi Valley was profound. Prior to the advance of the first ice sheet, much of the
present Mississippi drainage is thought to have flowed northward. The southward-advancing ice sheet blocked such drainage and eventually raised the level of the resulting ice-front lake to a point where the ice-ponded water sought an outlet through the lowest available southern divide. The resulting drainageway channeled glacial meltwaters southward along what is presently the axis of the Lower Mississippi Valley and forever altered the drainage of the North American continent. Where before the Gulf of Mexico received sediment only from small streams that drained a small portion of the continent, reversal of drainage caused by glaciation inaugurated the huge present Mississippi drainage system, which funnels water from about one-half the North American continent through the Lower Mississippi River to the Gulf (Figure B3).

32. The most recent ice advance occurred in late Wisconsin times or about 25,000 years ago. By 17,000 years ago, the ice sheet had reached the latitude of present-day St. Louis at its most southerly point and extended toward the east and west in a huge arc now marked by the Ohio and Missouri Rivers. Most of northern North America was overriden by continental ice. The moisture piled on land in the form of ice came largely from the world oceans; as the ice advanced, world sea level dropped more than 400 ft.

33. The outlines of the present floodplain of the Lower Mississippi Valley from Cairo, Illinois, southward to the Gulf (and of the western margins of the Loess Bluffs of the Yazoo Basin) were created during this time of glacial advance and lowered sea level. Meltwaters from the glacial front flowed southward at ever-increasing velocities as gradients increased in response to dropping sea level. Alluvial material left behind in the valley during the previous interglacial period was reworked by silt-laden waters flowing southward from the ice sheet. It was during this period of dropping sea level and during the subsequent rise as the ice sheet retreated that the loess was deposited (25,000 to 10,000 years ago). While the finest materials, the clays, remained in suspension and were carried to the Gulf, the coarser sands and gravels were left behind within the entrenched valley; the intermediate-sized particles, the silts, were swept by prevailing westerly winds from off
Figure B3. Mississippi Valley during the Ice Age (from Reference 1)
the Mississippi Valley and deposited on the bluffs that bordered the valley. The result was the formation of a blanket of loess about 20 miles wide along the eastern bluffs of the Lower Mississippi Valley from Cairo, Illinois, to the vicinity of Baton Rouge, Louisiana (Figure B3).

34. The deposit is about 90 ft thick, on the average, at the bluffs and gradually but irregularly thins eastward. Beyond this eastern boundary of the Loess Bluffs and extending for another 30 to 40 miles farther to the east is a sporadic deposit of what is called brown loam in the literature. It varies from a few feet to perhaps 10 ft in thickness and is generally recognized as windblown silt and clay similar in origin to the loess but reworked by physical, chemical, and alluvial processes to the point where it no longer has the properties or the general appearance of the undisturbed loess of the Loess Bluffs. In essence, its calcareous content has been leached, and its constituent particles have become so weathered that there is a decided increase in clay content when compared with the undisturbed loess of the Loess Bluffs. It will not stand vertically. It corresponds, in effect, to the upper few feet of the Loess Bluffs where leaching and illuviation have formed an A-horizon. Much of the North Central Hills of the Yazoo Basin are covered with brown loam, and interesting and useful distinctions are possible between it and residual soils developed on the ancient Tertiary formations.

35. Deep highway cuts made particularly in the past two decades have disclosed interesting, hitherto unknown features in the loess. Ancient loess strata have been found that probably correspond to a much earlier glacial-interglacial cycle (80 to 120 thousands of years ago). The remains of mastodons and other Ice Age mammals are being disinterred in increasing numbers. Man's arrival in the area perhaps 15,000 years ago may have corresponded with the extinction of the mastodons. To date, no human artifacts have been found together with Ice Age animal remains, which would suggest a connection between man's arrival in the valley and the demise of Ice Age fauna. However, such a find remains a possibility.
36. More pertinent perhaps has been the history of agriculture in the Loess Bluffs. Although available data are far from conclusive, there is evidence that early settlers found large flat areas within the Loess Bluffs that they promptly cleared of virgin forests and planted or used for pasture. Today such flat uplands are extremely rare. There is good evidence that headward growth of gullies became pronounced in a few decades, so much so that farming the Loess Bluffs became impractical and even grazing became marginal economically. The amount of loessial silt that moved down the many small creeks and rivulets into the Mississippi Alluvial Plain was pronounced; and the effect of gullying and siltation has continued, perhaps at a somewhat lesser rate, through to the present.

37. At the present time agricultural practices are less responsible for continued sedimentation problems than are the extensive grading and other earthmoving necessary for construction of new highways, new housing developments, new industries, etc. Equally troublesome from the standpoint of adverse sedimentation is the exploitation of the sand and gravel that often lies beneath the loess.

38. In some areas these exploitable sands and gravels reach the surface, but most of these sites have long since been developed. As sand and gravel become more difficult to find, it is inevitable that more and more sites will be opened where tremendous quantities of loess overburden must be removed. The effect of the sluicing of loessial silts and the unwanted fine sand that is often associated with sand-and-gravel operations will pose severe problems to planners concerned with environmental, flood-control, and sedimentation factors.

39. The geologic section in Figure B2 schematically illustrates the stratigraphic position of these gravels beneath the loess. The contact between gravel and the underlying Tertiary is erosional and erratic, and sand and gravel units may vary from high gravel-low sand content strata to strata that are essentially all sand. Thickness may vary from 80 ft to less than a foot. In some instances the loess rests directly on Tertiary. Because of these depositional and erosional irregularities, areas where gravel can be profitably exploited in the Loess Bluffs are difficult to predict. However, it is inevitable that
more and more effort will be expended toward predicting and testing for the presence of and eventually exploiting these valuable resources.

40. The origin of the Pleistocene sand-and-gravel units is thought to be the same as that of the sand-and-gravel substratum that underlies the present Mississippi Alluvial Plain (to be discussed later). The sand-and-gravel units beneath the loess are considered to be remnants of older alluvial plains of the Mississippi formed during previous ice advances and retreats and now uplifted to higher elevations. Only the deepest and coarsest portions of these old alluvial plain remnants are now left beneath the loess. Within the Yazoo Basin the Pleistocene sands and gravels are assigned chiefly to the Bentley and Williana terraces, ranging in age from about 800 thousand to 1.5 million years.

**Mississippi Alluvial Plain**

41. The Mississippi Alluvial Plain covers approximately two-thirds of the Yazoo Basin, an immense flatland shaped like a football with Memphis at its northern end and Vicksburg at its southern end. The area is referred to as the Yazoo Basin or the Yazoo Delta. Obviously the term Yazoo Basin is a misnomer since the area does not include the upland area of the Yazoo Basin. Calling it the Yazoo Delta is also incorrect since the Yazoo is tributary to the Mississippi and has no true delta of its own. But the term Yazoo Delta is well established in the literature and will be used in the discussion that follows. Certainly this is less cumbersome than referring to the area as the Mississippi Alluvial Plain portion of the Yazoo Basin.

42. The Yazoo Delta is one of the most fertile and productive regions in the State of Mississippi. Its lack of relief and its high concentration of sluggish streams and lakes contrast markedly with the upland areas of the Yazoo Basin. The eastern border of this physiographic unit is well defined by the steep escarpment of the Loess Bluffs. Its western border, also the western border of the Yazoo Basin, is along the top of the artificial levee that borders the Mississippi.

43. From the air the Alluvial Plain presents a surface that, though
flat, is far from featureless. Natural drainage follows arcs, loops, and the generally curved patterns characteristic of meandering streams rather than the dendritic patterns (bifurcating headward like the branches of a tree) characteristic of the upland areas of the Yazoo Basin. It is obvious in such an aerial view, moreover, that small streams quite often follow broad arcuate patterns that are not of their own making. In many instances these smaller streams have formed small tightly looped meanders, commensurate with their flow, within the broad arcs left by relict Mississippi River courses. Plowed fields reveal the remnants of huge meanders now marked only by light- and dark-colored arcs that extend for miles in either direction. Horseshoe-shaped lakes that were once obviously parts of the Mississippi River are now tens of miles distant from the Mississippi. In some instances the Yazoo River, the Big Sunflower, and other streams follow along the huge arcs left by the Mississippi. In other instances they disregard these abandoned courses and have formed their own courses in the lowland areas away from the large, formerly occupied channels.

44. In short, the Mississippi Alluvial Plain is largely the result of a complex history of occupation and deposition by ancient meandering courses of the Mississippi River and its tributaries. Contrasting with the widespread areas of sinuous meander scars and meandering drainage are isolated remnants of two distinctively different landforms (Figure B4). One consists of low-lying areas of interior drainage, the backswamp, where floodwaters once ponded and where clays have been deposited to depths of 50 ft or more. The other landform consists of silts and sands laid down by an anastomosing network of shallow drainage channels left behind when the Mississippi was a braided rather than a meandering stream. These are the remnants of the most ancient of the soils that form the surface of the Yazoo Delta, remnants left behind when the Mississippi was still choked with glacial debris from the last retreating glacier.

45. Present geologic data suggest that the Mississippi was a braided stream throughout much of the time its valley was being entrenched during the latest glacial advance and during the subsequent
Figure B4. Distribution of backswamp, braided stream, and meander belt deposits in the Yazoo Delta (after Reference 2)
rise in sea level as the glacier retreated, the time span between 23,000 and 8,000 years ago. There is little evidence that the entrenched valley was ever swept entirely free of silt, sand, and gravel as is shown schematically in Figure B2. On the contrary, borings that have penetrated the sand-and-gravel sequence invariably encounter ancient underlying Tertiary deposits that are unoxidized. Had the Tertiary been exposed, even for fairly short periods of time, the results of weathering and oxidation would have been apparent at this contact. Instead, a boring within the Alluvial Plain normally progresses through a clayey or silty topstratum into fine sand, then into medium and coarse sand mixed with increasing amounts of gravel with depth. The contact at the base of the sand and gravel is normally abrupt and well defined. Most of the Yazoo Delta is underlain by the highly plastic marine clays of the Yazoo formation, and cored samples of the contact show sand and gravel lying directly on unoxidized dark gray clay.

46. The obvious conclusion is that during its entrenchment, the Mississippi Valley was the scene of shifting bars of sand and gravel where the silt-choked braided drainage from the glacier scoured and continually reworked these coarse materials. During major floods, isolated drainage channels would scour deeply enough to reach the underlying Tertiary deposits; but as the periodic floods subsided, the Mississippi became once more an uneven plain consisting of sand and gravel bars around which a complex braided network of drainage flowed. These sands and gravels underlying the Alluvial Plain are called the substratum. They lie above the irregularly entrenched Tertiary strata and in some portions of the Yazoo Delta reach a thickness of 300 ft. The amount of groundwater in storage in the substratum beneath the Yazoo Delta is enormous. It is estimated at about 1000 billion cubic yards. The water table is nearly at the surface in most areas, and the exploitation of this readily available source of constant-temperature water is increasing yearly. The overall effect of such exploitation is an important consideration in planning the future development of the Yazoo Basin.

47. As sea level began its final rise about 17,000 years ago, as
the seaward gradients lessened, and as the ice front retreated toward
the north, aggradation within the entrenched valley increased. It is
estimated that by 9000 years ago, the Yazoo Delta was still a complex
network of shallow channels of a braided Mississippi River that was re­
working and depositing materials at essentially the same level as that
of the present Alluvial Plain. Drainage was still silt-choked. And
whereas formerly the silt and clay sizes were carried all the way to the
Gulf by the surface streams or were being carried by winds onto the easter­
n valley wall forming the Loess Bluffs, silt and clay sizes were now
being deposited at the surface. Sediment concentrations became progres­
sively less; and eventually at the southern end of the valley, shallow, multichanneled braided streams coalesced and formed single, deep mean­
dering channels. The meandering habit worked its way northward and
eventually affected that part of the valley that includes the Yazoo
Delta. Only a few remnants of the former braided surface remain. In
the Yazoo Delta one large remnant occurs near Greenville. The other
flanks the valley wall north of Greenwood (Figure B4).

48. The Mississippi River began its meandering habit perhaps as
long as 8000 years ago in the Yazoo Delta. Detailed geologic and en­
gineering soils mapping on inch-to-the-mile quadrangles^ delineates
deposits left by four or possibly five distinct meander belts that have
crossed the area. Saucier 2 has assigned dates to these meander belts
based on recent archeological and carbon-14 determinations and has fit
them into a consistent chronologic sequence (Figure B5). Saucier differs
from Fisk, 4 who attempted a similar chronologic assessment in 1944,
principally in that he considers Fisk's age assignments too recent.
Current data suggest that the various meander belts are older, some­
times as much as 2 to 3 times older, than Fisk had proposed.

49. Regardless of their ages, the occupation and eventual abandon­
ment of each meander belt are the most important chapters in the forma­
tion of the Alluvial Plain. The term meander belt should be understood
to appreciate the full significance of this geomorphic process. A mean­
der belt is a zone within which a meandering river migrates but from
which it does not escape. The Mississippi and other meandering streams
Figure B5. Chronology of the surface deposits forming the Mississippi Alluvial Plain of the Yazoo Basin (after Reference 2)
seldom migrate laterally for any great distance. In the 50- to 80-mile-wide floodplain of the Mississippi, bends migrate laterally as they grow, but eventually they form a loop with a narrow neck. During floods, floodwaters chute across this neck. Eventually the loop is cut off, and the river assumes a shorter course as it returns to a centrally located position within the meander belt. Meander belts along the Mississippi are seldom more than 12 miles wide. At some point in its history, the river chooses another path, a path that becomes available when, for example, it migrates into another stream that affords a gradient advantage. At this point water is gradually, or sometimes rapidly, diverted into the new course and an entirely new meander belt begins to form.

50. It should also be understood that as each meander belt is abandoned, the new meander belt is free to migrate into and partially or entirely destroy the older abandoned meander belt. As a result, only segments of the older belts remain and are distinguishable at the surface. Using these segments as guides, the positions of the various meander belts are shown on Figure B6. Segments of each belt still remaining are shown in black. Inferred positions of the meander belt are shown as dotted areas.

51. The oldest meander belts are along the eastern valley wall. Because of their age and the few segments exposed at the surface, the history of these belts is far from certain. Meander belts 1 and 2 are shown as essentially the same belt on Figure B6 throughout most of the Yazoo Delta. The two belts were probably combined as far south as Vicksburg before they split. However, there is some evidence that a large segment of meander belt 2 forms the surface in an area northwest of Greenville. If future studies prove this to be true, the course of meander belt 2 is more complex than is indicated in Figure B6; rather than a single belt as far south as Vicksburg, there may have been two fairly widely separated belts. Much more certain is the split between the two belts just north of Vicksburg. Here the older meander belt continues south along the valley wall and about 7000 years ago was abandoned in favor of meander belt 2, which trends to the east and then
south and is now partly occupied by the headwaters of the Tensas River in Louisiana. The deltas associated with these two meander belts are probably buried beneath the present deltaic plain.

52. Meander belt 3 (Figure B6) is broad, well defined, and well preserved. The final course of the Mississippi River within this belt is now followed for much of its length by the Big Sunflower River. It probably began by diversion from the combined meander belts 1 and 2 northwest of Memphis about 6000 years ago and was occupied by a full-flow Mississippi River for about 1500 years. It is the first of the relict meander belts trending through the Yazoo Delta that can be traced downstream to its delta. South of the Yazoo Basin, in Louisiana, meander belt 3 follows the Teche ridge along the western side of the Atchafalaya Basin, trends through Morgan City, and culminates in the marshes of south Louisiana as the Teche Delta, the oldest of the Mississippi River's deltas discernible at the surface.

53. Meander belt 4 is an interesting dual, split-flow situation characterized by meanders that are only about half the size of a full-flow Mississippi River. The smaller meanders are particularly well preserved along the eastern valley wall where many are now followed by the Yazoo and the Tallahatchie Rivers. Fisk considered these to have been left by the Ohio River, which he postulated to have followed a separate course at this time as far south as Vicksburg where it was presumably joined by a Mississippi River, which, without the flow of the Ohio, would have been a stream of about the same size as the Ohio. Saucier concluded that the geometry of the floodplain near Cairo, Illinois, was such that the Ohio and the Mississippi could never have flowed in separate meander belts at this time. An alternative explanation is that meander belt 3 was gradually abandoned as water was diverted into the eastern arm of meander belt 4 and that some time after belt 3 was abandoned, about half the Mississippi's flow was diverted through the western arm of meander belt 4 (Figure B6). Thus flow was divided through the Yazoo Delta for a considerable period of time estimated to be from about 4500 to about 2500 years ago. Eventually the western arm of meander belt 4 enlarged to accept the full flow of
a. Approximate position of meander belts 1 and 2. About 9000 to 6000 years ago.

b. Approximate position of meander belt 3. About 6000 to 4500 years ago.

c. Approximate position of meander belt 4. About 4500 to 2500 years ago.

d. Position of present meander belt (5). 2500 years ago to present.

Figure B6. Yazoo Basin meander belts (after Reference 2)
the Mississippi and the present meander belt 5 (Figure B6), was formed.

54. As mentioned previously, detailed maps are available of the entire Yazoo Delta showing the distribution of the geologic environments of deposition. Natural drainage patterns, limnological features, soil types, relief, and landscape types are significantly influenced by the geologic environment in which they occur. The following paragraphs, therefore, briefly describe the more important Alluvial Plain environments and, where appropriate, briefly explore some of the changes in these environments caused by flood-control projects and by agricultural development of the area.

55. Alluvial environments of deposition within the area are divided into (a) braided stream remnants (b) backswamp, (c) point bar, (d) abandoned channels and abandoned courses, (e) natural levees, and (f) alluvial aprons.

Braided stream remnants

56. Braided stream deposits consist of the most ancient sediments exposed in the Alluvial Plain, sediments laid down by a network of shallow, shifting streams. Although by far the greater mass of the sediment was coarse grained (hence included in the substratum), a thin, fine-grained portion is present. This topstratum portion also includes fine-grained, relict, alluvial fan and apron deposits near the valley walls that apparently accumulated continuously during the period of substratum deposition. Figure B7 shows the relationship of the braided stream deposits near the valley wall to the alluvial aprons (to be discussed later) and the relict alluvial fans.

57. Braided stream deposits are exposed in the northeastern and west-central portions of the Yazoo Delta (Figure B4). These areas remain as remnants of once larger masses now situated between meander belts or a meander belt and the valley wall. Present-day drainage largely disregards the former network of braided channels. One or two of the larger of these former channels are usually selected for enlargement, and present drainage within the selected channel is usually sinuous and meandering. In other portions of the Mississippi Alluvial Plain, the braided stream surfaces often stand as low terraces above the level of
Figure B7. Sketches of selected alluvial environments of deposition (from Reference 3)
the rest of the Alluvial Plain. In the Yazoo Delta, braided surfaces are essentially at the same level or only slightly higher than the bordering alluvial environments. Because of this slight elevation differential, the braided surfaces were chosen early for farming. No definitive data are presently available, but it is probable that elevations on the large braided surface in the west-central portion of the study area (Figure B4) have been reduced a significant foot or more by wind deflation, water erosion, and agricultural exploitation.

Backswamp

58. Backswamp deposits consist of fine-grained sediments laid down in broad, shallow basins within the floodplain during major periods of stream flooding. The sediment-carrying floodwater may be ponded between the natural levee ridges on separate meander belts or between natural levee ridges and the uplands. Backswamp areas typically have very low relief and a distinctive, dendritic drainage pattern in which the channels alternately serve as tributaries and distributaries at different times of the annual flood cycle.

59. Backswamp deposits are present in various portions of the Yazoo Delta, but are widespread only in the southern portion where they occur between meander belts (Figure B4). Soils consist of heavy plastic and organic clays that settle out in sheets that vary from paper thin to inches thick. On drying, these highly plastic clays tend to contract and break up into countless small, extremely hard blocks or pellets, thus the name "buckshot" clays that is often applied to them. When wet, the buckshot clay is anything but hard. It forms a sticky, gummy mass that adheres to the shoe soles in ever-increasing thicknesses as one walks through it. In its wet state the clay is known by the equally descriptive name of "gumbo." Pedologists classify the material as Alligator clay. It should be pointed out that fine-grained, highly plastic clays are not found exclusively within the backswamp, and the names "buckshot" and "gumbo" are also applied to highly plastic clays in other geologic environments of the Yazoo Delta. But the greatest concentrations of these clays are within the backswamp.

60. Since floodwaters are no longer permitted to flood the
backswamp areas periodically and add to the sediment that once accumulated within them, the backswamp surfaces are probably gradually decreasing in elevation. Some of these clayey deposits are 50 or more feet thick, and normal compaction tends to lower these surfaces with time. As a rule, these low-lying areas were not used for farming until comparatively recent times. As cultivation increases, however, many of these areas are cleared of timber and drained artificially. The overall impact of such activities within the backswamp on Yazoo Delta ecology is as yet undetermined.

Point bar

61. Point bar deposits consist of sediments laid down on the insides of river bends as the river meanders. There are two types of deposits within the point bar topstratum: silty or sandy elongate bar deposits or "ridges" that are laid down during high stages of the stream and silty and clayey deposits in arcuate depressions or "swales" that are laid down during falling river stages. Characteristically, the ridges and swales form an alternating series, the configuration of which conforms to the curvature of the migrating channel and indicates the direction and extent of meandering (Figure B7b). Point bar deposits are by far the predominant sediments in the Yazoo Delta. They owe their origin to migration of full-flow and partial-flow Mississippi River courses as well as to the migration of smaller streams such as the Yazoo and the Big Sunflower. Successive occupation of many areas by different streams of different sizes has resulted in complex patterns of ridge-and-swale topography.

62. Sandy silt and clayey silt are the predominant soil types found in the ridge areas, and sand is sometime found at the surface or only 5 to 10 ft below the surface. The swales are the sites of elongate bodies of plastic clays, generally from 5 to 20 ft deep. Point bar areas are characteristically cleared of timber and cultivated in the Yazoo Delta, and the natural drainage patterns have been drastically altered since the advent of the white settler. Topographic differences between the tops of the ridges and the intervening swales are gradually being eliminated through intensive cultivation. Swales were often the
sites of shallow, crescent-shaped lakes and stands of virgin cypress. Drainage and cultivation have all but eliminated these once-common shallow water bodies in the Yazoo Delta.

**Abandoned channels and courses**

63. Abandoned channels are partially or wholly filled segments of meandering streams formed when the stream shortens its course. Soon after formation, they exist as horseshoe-shaped or oxbow lakes that gradually become filled with sediment-laden floodwaters. The abandoned segment may represent an entire meander loop formed by floodwaters cutting across the narrow neck of the loop (a neck cutoff); or it may represent only a portion of a loop formed when the river occupied a large point-bar swale and abandoned the outer portion of the loop (a chute cutoff). Eventually the surfaces of abandoned channels may be entirely silted over and obscured. Through careful study of aerial photographs, these buried abandoned channels can sometimes be detected and delineated; soils borings readily identify the abandoned channel deposits. They consist of thick, high-water-content, highly compressible clays. The clay bodies, often called clay plugs, are sometimes as deep as the former channel of which they were a part, and as wide, i.e. 100 ft deep and three-quarters of a mile wide. Such massive clay units, by far the thickest units within the topstratum, have served as important keys to river migration and valley history. Some represent full-flow Mississippi River courses; others, partial-flow Mississippi courses. Some are small fairly shallow clay-filled loops left by the Yazoo, the Big Sunflower, and other minor streams. Hundreds of these clay plugs have been entirely destroyed by subsequent river meanderings, and hundreds of others exist only as small remnants of once much larger clay bodies. Those that have been mapped within the Yazoo Delta are shown in Figure B8.

64. The hundreds of lakes that were formed as abandoned chute or neck cutoffs are an important environmental heritage of the Yazoo Delta. The construction of the levees effectively prevents silt-laden floodwaters from filling them with sediment as would be their eventual lot under natural conditions, and thus has considerably extended the life
Figure B8. Distribution of mapped abandoned channels and abandoned courses in the Yazoo Delta. Dark areas consist of point bar deposits of the meander belts (from Reference 3)
of these water bodies. On the other hand, the influx of periodic floodwaters tended to flush and freshen these water bodies. This is particularly pertinent since pesticides and other pollutants have all but destroyed the value of many of these lakes for fishing.

65. Figure B8 includes abandoned courses distinguished from abandoned channels. These are lengthy segments of the river abandoned when the river shifted into an entirely new meander belt. They mark the final position of the river before it was abandoned. The abandoned courses are often occupied by smaller streams and bayous. On being abandoned by the Mississippi, these naturally available drainageways became the ancestral courses for minor drainage within the Yazoo Delta. The Yazoo, the Tallahatchie, the Coldwater, and the Big Sunflower Rivers used segments of the abandoned courses. Thus the present drainage network within the Yazoo Delta was inherited largely from the major Mississippi River courses that once traversed the area.

66. Figure B9 illustrates the interrelation among various geologic environments of deposition in a portion of the Yazoo Delta near Greenville. The figure is schematic but typifies the geometry of the present and abandoned meander belts vis-a-vis the backswamp and braided stream deposits and the distribution of these geologic environments and their associated soils in plan and profile. An important surface environment not yet discussed and that is illustrated on the figure is the natural levee features that flank present and abandoned streams.

**Natural levees**

67. Natural levees are broad, low ridges that flank both sides of streams that periodically overflow their banks. Since the coarsest and greatest quantities of sediment are deposited closest to the stream channels, the natural levees are highest and thickest in these areas and gradually thin away from the channels. In general, the greater the distance from the stream the greater the percentage of the finer-grained sediments (Figure B7). Small drainage channels trending at right angles to the parent stream (down the backslope of the levees) are common; major crevasses are indicated when these channels are large and pronounced. Abandoned crevasse channels are often filled with sediments that are
Figure B9. Major environments of deposition and associated soil types in the vicinity of Greenville (from Reference 5)
distinctly coarser than the remainder of the natural levee.

68. The largest and most widespread natural levees in the Yazoo Basin occur along the present course and abandoned courses of the full-flow Mississippi River. They attain crest heights of 10 to 15 ft above the adjacent backswamp level and may be as much as 2 miles in width. Typical natural levee deposits consist of stiff to hard, light-tan to grayish-brown silts and silty clays. They are usually well drained and because of their height were the first areas that were inhabited and cultivated within the delta.

69. Because of the complex distribution of the abandoned channels and courses within the delta, the natural levees that flanked them are distributed in an equally complex fashion. Some have subsided below the general surface level; but in its natural state, the Yazoo Delta consisted of innumerable areas of interior drainage bounded by natural levee ridges. Naturally developing drainage tended to tap these areas as it did the backswamp areas and drain them; however, the rate of such drainage was very significantly increased by agricultural and flood-control interests, particularly during the past century. What adverse effects, if any, such accelerated drainage may have had on the ecology of the Yazoo Basin is undetermined.

Alluvial aprons

70. A final environment of significance in the Yazoo Delta is the alluvial aprons near the valley walls. Alluvial aprons are broad, gently sloping features composed of both alluvial and colluvial deposits that concentrate at the base of the valley walls. Typically, symmetrical alluvial fans are present at the mouths of streams that drain the uplands. When the streams are closely spaced, the fans coalesce to form the alluvial aprons. When the streams are widely spaced, the fans are separated; the intervening portions of the aprons are less well developed and composed mainly of sediments introduced from the uplands by mass wasting and surface wash (Figure B7).

71. These aprons occur at the base of the valley wall from Memphis to Vicksburg. They are exceptionally well developed at the points where streams, such as the Tallahatchie River, discharge from the uplands and
have constructed large alluvial fans. Reflecting the widespread presence of easily eroded loess in the uplands, the alluvial aprons characteristically are composed of silt with subordinate amounts of clay and fine sand. Occasional gravel and large rock masses are present where Pleistocene and Tertiary formations are exposed nearby in the uplands. The apron deposits are generally fairly high with respect to the remainder of the delta and are well drained. Where the river in the past has meandered against the bluffs, they form a distinctive cover over meander belt deposits, a cover that next to the valley wall may be more than 15 ft thick. Because of their location at the junction between the uplands and the Alluvial Valley, archeological sites are fairly frequent on the alluvial aprons. It is probable that many archeological sites may lie buried by the successive waves of alluviation that formed these aprons.

Artificial levees

72. Prior to the advent of the white man, and particularly prior to the construction of the massive levee system that now protects the area, the physiography of the Yazoo Delta was largely controlled by the mighty river that bordered it on the west. Periodically the Mississippi rose in response to melting snow and rainfall in its upstream tributary basins. As the river rose, it began to back up into the Yazoo; and the Yazoo, in turn, into its tributary stream and bayous. Depending on local rainfall, the streams of the Yazoo Delta added to the flood heights. As a result, a relatively thin sheet of silty floodwater often accumulated in the lower backswamp areas between the active and relict natural levees.

73. Desoto, the first white man to enter the region, characteristically saw the Mississippi during flood. He recorded that flooding began about the tenth of March 1543 and that the river returned to its banks by the end of May, having been in flood for about 80 days. The Indians who dwelt along the river's banks and within the basin stoically climbed into their huts built on stilts or traveled to higher ground until the flood subsided. Long after the Mississippi had returned to its channel, stagnant waters remained in countless low places within the
poorly drained, almost featureless floodplain. The natural levees along the river served to contain the river at heights somewhat more than bank-full stage, but they also effectively prevented floodwaters that breached or overtopped these natural dikes from returning to the river. The result was that early geographers characterized most of the Delta as swamp, in many places an impenetrable jungle of mud and alligators.

74. As late as the 1830's the only means of travel within the delta was along the rivers and bayous that drained the area and along a few Indian trails open during the dry season. But the delta's potential was not lost on the early travelers who wrote about the region. Properly drained and protected from flooding, it was considered to have one of the highest agricultural potentials in the country. The Mississippi State Geologist wrote in 1857:

The alluvial plain is in an agricultural respect, one of the most important formations not only in the State of Mississippi, but in all the Southern States: nay, more than that, even in the United States. It is still a wilderness; the prejudice of its unfitness for cultivation has only lately subsided, and the axe of the woodman scarcely begun its ravages; but after the lapse of another century whatever the delta of the Nile may once have been, will only be a shadow of what the alluvial plain of the Mississippi will then be. It will be a central point--the garden spot of the North American continent--where wealth and prosperity culminates.

75. The virgin forests of the delta were equally attractive to the timber merchant. Locust, hackberry, sweet gum, elm, maple, oak, ash, walnut, and pecan grew to prodigious heights and diameters on higher ground. Cypress, tupelo, and sweet gum measuring 6 ft in diameter were common in the sloughs, the abandoned channels, and the backswamps.

76. The Yazoo Delta's early settlers took the higher lands immediately adjacent to the rivers. The natural levees bordering the Mississippi were selected first because of their immediate availability to the river commerce. Later comers settled along the natural levees of the lesser Yazoo Delta streams. Settlement thus concentrated along the strips of natural levees with intervening lower lying swamplands. Because floods could spread throughout the lower areas, the lands of the earlier settlers were inundated only by the larger floods and then
to depths of only a few inches. Thus, low, frail embankments constructed along the edge of the river with wings or lateral banks running back into the swamp afforded ample protection for the pioneer farmer.

77. As more and more such levees were built, however, a new problem arose. It was noticed that where once 3-ft-high levees did a passable job in protecting against flood flow, flood stages were now so high that 6- or 9-ft levees were needed to do a comparable job. In the early 1900's, there was considerable concern that the river was gradually silting in between the levees and raising its bed so that eventually it would flow in a channel dangerously high above the alluvial plain. Careful studies, however, conclusively proved that this was not the case. The bed of the river remained at an overall constant level. As had been expected, however, there was a rise in flood stages. This was due to the confinement of the flood flows. Where once these flows had been allowed to spread out across the 50-mile-wide floodplain, they were now kept within the narrower confines dictated by the levees. Of interest was the fact that floods of similar magnitudes, because of the increased gradient due to the increased flood stages, were carried to the sea much more quickly than before. The flood flows now reached the sea in record time.

78. Gradually the levees were lengthened and increased in size. Where the levee of 1882 was 9 ft high with a cross-sectional area of 300 sq ft, levees at the present time are 30 ft high and 5000 sq ft in cross-sectional area. As a result of the 1973 flood, it was determined that present levees along the Yazoo Delta and opposite the delta in Louisiana were not sufficiently high to contain the so-called "project flood." Levees are therefore being heightened by several feet.

79. A serious development within the Yazoo Delta, one that if consummated would require even higher levees, is a concerted effort by many agricultural interests to protect the southern end of the delta from flooding. The delta surface slopes erratically from west to east, depending on the disposition and age of the meander belt and the associated geologic environments along an individual transect. The delta also slopes from an elevation of about 210 ft at its northern end
to about 90 ft at its southern end. Consequently the lowest and wettest lands are in the southernmost tip of the delta, just north and northwest of Vicksburg. For decades this area has been designated the Yazoo Backwater Area, a natural sump into which floodwaters can spread and from which these floodwaters can drain naturally as flood stages on the Mississippi subside.

80. As cotton and soybean acreage expands into these areas, however, flood-control planners are besieged by local interests to protect more and more of the Yazoo Backwater Area for the production of food and fiber. The Corps of Engineers is faced with conflicting interests among economic, agricultural, environmental, and flood-control groups. Some of the factors that must be considered in resolving these conflicting interests are outlined below. Most fall in the category of unresearched ideas and, though tentative, should receive consideration and possible future research effort.

81. Serious thought should be given, before agricultural and industrial development has completely preempted the land, to retain or even increase the size of the Yazoo Backwater Area. Wildlife and fishing interests would heartily welcome the retention of this area as a swamp. More important, backwater is a necessary and very critical part of the flood-control system, and the gradual inroads of levees and other expensive protective works can only decrease its viability as a sump for flood flows.

82. Similarly, the Corps might seriously consider moving the mainline levees along the Mississippi as far landward of the river as possible. Land acquisition costs, municipal interests, etc., would, of course, be important negative factors; but a wider batture on both sides of the present river would provide extremely welcome overbank storage for flood flows. A serendipitous result of such a policy, and one that might pay for itself in the long run, is that the wider batture would allow the Mississippi more room for meandering, which would significantly lower costs for revetment and similar bank stabilization efforts.

83. Of no small concern is the specter of a 35- to 40-ft-high levee that might eventually be needed to protect the Yazoo Delta.
Such embankments could, of course, be constructed; but where they crossed soft swale or channel fill deposits, their basal cross sections would have to be so wide to be stable that valuable farmland they are designed to protect would be preempted by the levee itself. Where the levee crossed the permeable point bar deposits, on the other hand, the landside berms that would be necessary to prevent underseepage caused by the increased hydraulic head of the project flood would also be wasteful of the farmlands along the levee rights-of-way.

84. An even more serious concern is the frighteningly large amount of underseepage that could be expected during high or project floods. Besides the possibilities of uncontrolled seepage or piping and failure of the levee, the sheer amount of water that would seep beneath the levees is frightening. Add to this the even larger volume of precipitation that might fall within the Yazoo Delta, and the amount of water that would have to be handled is enormous. It is understood that a proposed pumping station near Vicksburg would have to pump an estimated 20,000 cfs up and over the levee during floods. Such a pumping plant would not only be expensive to build and to maintain but would use valuable energy in an energy-short economy.

85. Establishing a large permanent area for flood dissipation in the Yazoo Backwater and increasing the batture area where possible between main-line levees on the Mississippi for acceptance of more overbank flow would have other desirable effects. Many of the oxbow and similar lakes within the Yazoo Delta are already, or are fast becoming, so polluted with pesticides and nutrient contaminants that they are almost useless for fishing. Only those lakes on the river side of the levees and in the unprotected backwater areas have escaped this fate. The reasons are obvious: less agricultural exploitation and flushing of these water bodies during floods. Thus, a systematic and carefully planned increase in acreage on the river side of the levees would not only permit lower levees for the protected areas, but would set aside valuable lands for promotion and preservation of wildlife and fisheries. Moreover, portions of the backwater and batture areas could still be designated for crops and pasturage between floods. Such land is far
from lost to the production of food and fiber.

86. To summarize, just as levees are an integral part of the flood-control system without which the Yazoo Delta could never have reached its present state of economic and cultural development, overbank areas for the accommodation of flood flows are important and integral factors for controlling Mississippi River floods. Unless sufficient such overbank areas are maintained, levees and adjunct drainage facilities can become abnormally large and wasteful. Careful studies are needed of the decrease in stage height that would result from variations in the size and location of backwater and batture areas. Such studies can be correlated with agricultural, environmental, and economic requirements to plan where such overflow areas could best be located. Similar criteria could also be used to zone the overflow areas selected for use by farming, timber, industrial, and wildlife and fishing interests.

Environmental and Baseline Studies

87. One of the objectives of this study was a systematic review of existing knowledge of the water and related land resources of the Yazoo Basin. The preceding discussion reviewed the geologic and physiographic development of the basin with occasional comments concerning the alteration of existing physiographic features by agricultural, flood-control, and related interests.

88. In the following paragraphs, an attempt will be made to delineate those types of geologic, physiographic, and hydrologic data that should be available to permit the basin planner to evaluate properly the impact of such data on water resource problems as they arise. Methods of presenting the data are suggested, and estimates are made of the effort that will be necessary to compile the information in the suggested form. Geologic, physiographic, and hydrologic data sometimes interface with other data types, but no effort will be made to stay within a rigidly defined disciplinary framework. What is presented here can best be described as a "shopping list" that will undoubtedly overlap with "shopping lists" suggested by other members of the research
team concerned with the impact of factors within their particular disciplines. Better definition and the elimination of such overlap can best be accomplished as the study develops.

Maps

89. Baseline data of a physiographic, geologic, or hydrologic nature within a given river basin is often advantageously displayed on maps, to which tables or graphs are keyed should they be needed for clarity and completeness. It is suggested that a scale of 1:250,000 be used for presentation of the map data. Excellent topographic maps of the Yazoo Basin are available at this scale, and such a scale would be necessary for properly displaying much of the physiographic, geologic, and hydrologic data. The Yazoo Basin at such a scale would require a map measuring about 33 in. in its east-west dimension and 50 in. in its north-south dimension. A folio of maps of this size would be unwieldy. However, if the maps are split in half along their east-west axis and bound with a ring binder so that they would lie flat, they could be conveniently contained in a folio 33 in. by 25 in. The inset in Figure B10 illustrates such an arrangement.

90. Figures B10-B14 and B16-B22 are tentative mock-ups for the 12 types of physio-geo-hydrologic baseline data suggested for display. Figure B15 shows the quality of geologic data available for use in preparing the map on pre-Quaternary geology (Figure B14). Suggested illustrative legends are also included. Table B1 lists estimated costs for preparation of each map and suggests a possible group or combination of groups capable of preparing and willing to prepare each map. Much of the baseline data could also be incorporated into the Resources Information System (RIS) discussed in the Summary Report. Depending upon the final system design, the RIS could provide an alternative source of map-producing capabilities.

91. A table should be prepared in the 25- by 33-in. folio format that correlated landforms and associated surface geology with soils and vegetative cover. The format used in References 7 and 8 or some modification of this format should be considered. An example of the correlation of the backswamp environment with soils and vegetative cover
This map will consist of a reprint of several of the 1:250,000 topographic maps that cover the Yazoo Basin. Portions of the Grenada, Helena, Greenwood, West Point, and Jackson sheets will be involved.

No basic data need to be gathered. The negatives and color overlays are available from the U. S. Army Engineer Division, Lower Mississippi Valley.

This space will include an up-to-date index of topographic quadrangle maps of the basin at all available scales.

Figure B10. Mock-up of topographic map of the Yazoo Basin
This map will consist of a black-and-white relief map showing a three-dimensional, bird's-eye view of the Yazoo Basin. Such maps have proved very useful to planners in providing an overview of a major physiographic division, a river basin, etc.

A relatively poor relief map of the State of Mississippi exists. Perhaps it could be used as a base for preparation of a relief map of the Yazoo Basin. The work should be closely coordinated with knowledgable geologists so that landform-relief, and geologic strata-relief associations would be properly depicted. Erwin Raisz of Columbia University has done the most to prepare and foster the publication of such maps. One of his maps of the eastern United States was used as a base for Figure B3.
One of the most important of the parameters that define a given landscape is the slope of the ground surface. Available topographic maps and stereoscopic study of aerial photographs would permit a useful and effective delineation of at least three categories of slope as indicated in the legend below. Where contour intervals are small, as is the case in the Yazoo Delta, and in some of the more recent maps in the uplands, meaningful subdivisions can be made within the categories of slope listed below.

---

**LEGEND**

- <5 deg
- 5-15 deg
- >15 deg

---

**SLOPE**

**YAZOO BASIN**

**SCALE**

10 0 10 20

MILES

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Figure B12. Mock-up of slope map of the Yazoo Basin
The landforms of the Yazoo Delta have been mapped in some detail by geologists of the U. S. Army Engineer Waterways Experiment Station (WES). Landforms of the uplands are essentially unmapped. The list of landforms in the legend below is tentative and would be changed where necessary.

**LEGEND**

- Natural levee
- Point bar
- Backswamp
- Abandoned channel
- Abandoned course
- Braided stream
- Alluvial fans
- Terraces
- Undifferentiate floodplains
- Dissected hills
- Undissected hills

**LANDFORMS**
**YAZOO BASIN**

**SCALE**

10 0 10 20 MILES

Figure B13. Mock-up of landform map of the Yazoo Basin
The pre-Quaternary or bedrock geology consists of soils and rock older than about 10 million years that underlie Quaternary soils of variable thicknesses. It occasionally reaches the surface. Available data on the distribution of pre-Quaternary strata range from good to poor as shown in Figure B15.

Because the pre-Quaternary is often buried to considerable depth, contours on the buried surface will be shown where this depth exceeds 20 ft. Contours beneath the Yazoo Delta based on sporadic boring data are available on maps prepared by Wes geologists. Elsewhere, these contours must be developed from field measurements, available borings, etc.

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**Figure B14.** Mock-up of pre-Quaternary geology of the Yazoo Basin
Figure B15. Quality of geologic data available on the pre-Quaternary strata
Quaternary soils in the study area range from about 1.5 million years to the present in age. Those within the Yazoo Delta have been mapped and data need only be transferred to a 1:250,000 base. Information on the upland area is sporadic and sparse. The precise areal extent and thickness of the loess, for example, are poorly known. The existence and thickness of underlying terrace gravel are known only in a few areas.

The occurrence of this valuable resource is most important to the economy of the basin, and its eventual exploitation will significantly affect the quality of the basin's water resources. Consequently, a concerted effort should be made to estimate and delineate this resource and the thickness of the loess overburden.

Figure B16. Mock-up of Quaternary geology of the Yazoo Basin
Soils have been mapped using the United States Department of Agriculture Component Soils Series for most of the counties in the Yazoo Basin. Soil-geologic landform associations are also available for about half the counties. The association indicated in Figure B16 is an example.

There is some controversy as to whether to use a Wentworth sand-silt-clay classification, or the Unified Soil Classification System (USCS). At this point, the modified Wentworth classification listed in the legend below seems preferable.

**LEGEND**

- Clay
- Silt
- Silty clay and clayey silt
- Silty sand and sandy silt
- Sand
- Sand and gravel
- Sandstone and siltstone
- Limestone
- Chalk and marl

Figure B17. Mock-up of soils and rock of the Yazoo Basin
The locations of historical and archeological sites within the Yazoo Basin are fairly well documented. An effort should be made, however, to document in equally comprehensive form the sites of geological interest. Fossil-collecting localities, geological type localities, vertebrate faunal sites, loess-travertine sites, silicified wood and palm localities, etc., should be assessed, described, and located on this map. The map will also require accompanying descriptive tables where the historical, archeological, and geological sites are described and their significance outlined.

Figure B18. Mock-up of historical, archeological, and geological sites of the Yazoo Basin
Mineral resources that have already been developed are fairly easy to assess and delineate. Mineral resource potential is much more difficult to assess and map. This is particularly true of the greatest of these mineral resources in the Yazoo Basin, the sand-and-gravel deposits.

This map should be accompanied by fairly extensive data on development and potential development of mineral resources within the basin.

LEGEND

- Sand and gravel (active)
- Sand and gravel (abandoned)
- Dendritic stone (differentiate)
- Salt domes
- Lignite
- Iron
- Bauxite
- Agricultural lime
- Cement
- Bentonite
- Blending clays
- Lightweight aggregate clays
- Brick and tile clays
- Oil
- Gas
- Geothermal/geopressed groundwater

MINERAL RESOURCES
YAZOO BASIN

Figure B19. Mock-up of the mineral resources of the Yazoo Basin
A great deal of work has been done by the U. S. Geological Survey and the Mississippi Geological Survey on groundwater resources of the study area. Depth to and normal variations in the shallow water table (normally less than 10 ft) in the Yazoo Delta have been studied by WES geologists. Two sets of contours of different colors would be used to depict this situation: one for the water table in the alluvium, the other showing the depth to the first moderate to large supply of soft water. Data on permeability, yield, transmissibility, etc., together with geologic sections illustrating various aquifers at various elevations in the Yazoo Basin would be included on separate sheets.

LEGEND

- Moderate to large quantities of soft water
- Moderate to large quantities of soft water at depth overlain by hard water at shallow depth
- Small to moderate quantities of soft water at depth overlain by hard water at shallow depth
- Small to moderate quantities of hard water at depth

Depth to groundwater in Yazoo Delta

Depth to uppermost aquifer capable of supplying moderate to large quantities of soft groundwater

Figure B20. Mock-up of groundwater potential of the Yazoo Basin
The drainage basins of second-, third-, and some fourth-order streams would be outlined using distinctive symbology or distinctive colors. Areal extent of each basin would be included on the map.

Gaging stations would be shown along each stream and maximum and minimum flow shown where data are available.

Where no gaging stations are available, the stream would be designated as perennial or ephemeral.

All lakes and ponds over 10 acres in extent would be mapped. A numerical symbology would be used to indicate parameters such as maximum depth, acre-feet, and seasonal variation in depth.

Data on points where municipal, concentrated agricultural, or industrial waste are emptied into the stream would be shown.

Additional sheets would be used to record discharge data, suspended sediment determinations, etc.

LEGEND
To be determined

Figure B21. Mock-up of drainage basins, lakes, and streams of the Yazoo Basin
Data on the transportation net, powerlines, and pipelines can be transferred to the 1:250,000 base from standard, large-scale quadrangle maps. Up-to-date information on new roads, pipelines, transmission lines, etc., can be obtained from State agencies such as the Highway Department and the Oil and Gas Board.

**LEGEND**

- Interstate highways
- Major paved highways
- Secondary paved highways
- Gravel and improved roads
- Dirt roads
- Railroads (active)
- Railroads (abandoned)
- High-tension transmission lines
- Standard power and telephone lines
- Oil pipelines
- Gas pipelines

**TRANSPORTATION NET, POWERLINES, AND PIPELINES YAZOO BASIN**

Figure B22. Mock-up of transportation net, powerlines, and pipelines in the Yazoo Basin
is given below. Similar correlations are envisioned for approximately 20 landform-surface geology types arranged in tabular form.

Geomorphologic Unit: Backswamp

General Description: Low-lying area between meander belts or between the meander belt and the valley wall. Deposits consist of fine-grained sediment laid down within these areas during flooding. The areas typically have very low relief and a distinctive, dendritic drainage pattern in which the channels alternatively serve as tributaries and distributaries at different times of the annual flood cycle.

Soils consist of heavy plastic and organic clays that settle out in sheets that vary from paper thin to inches thick. The name "buckshot" is applied to these clays when dry and "gumbo" when wet. Thickness of the backswamp ranges from about 50 ft in some portions of the Yazoo Delta to 10 ft where these deposits overlie meander belt deposits.

Component Soils Series: Sharkey and Alligator

Texture and Classification (USCS): dark gray and brown clay, CH and OH

Factors Affecting Use:

For Cropland: Needs drainage; high fertility; difficult to work and establish stands; good response to nitrogen fertilizer; poor trafficability.

For Forestry: Poor drainage; high fertility; occasional flooding. Important species: green ash, cypress, sweet gum, oak.

For Wildlife Management: Subject to flooding; high natural fertility. Supports deer, dove, duck, turkey, squirrel, crawfish, rabbits.

For Construction: Severe wetness; very high strength swell, occasionally peaty or highly organic, moderate bearing strength; very low permeability, poor subgrade material; subject to flooding; difficult to work.

Characteristic vegetative cover and land use: Woodland, pasture

92. Almost all the data contained in the baseline maps suggested in Figures B10-B14 and B16-B22 are geologic, geographic, or hydrologic in nature. Research groups involved with these disciplines who have expressed varying degrees of interest in working on the Yazoo Basin Study are as follows:
1. Geology and Rock Mechanics Division, Soils and Pavements Laboratory, WES
2. Mobility and Environmental Systems Laboratory, WES
3. Hydraulics Laboratory, WES
4. Geology, Geography, and Anthropology Departments of (a) Mississippi State University, (b) Louisiana State University, (c) University of Southern Mississippi, and (d) University of Mississippi
5. Groundwater Division, U. S. Geological Survey
6. Mississippi Geological Survey
7. Soils Conservation Service, Department of Agriculture
8. Other

93. Certain maps, the relief map suggested in Figure B11 for example, should be contracted out to a cartographic group specializing in such maps. The group chosen should work closely with the geologists and geographers preparing the other maps. The maps suggested in Figures B18, B19, B20, and B21 will require input from several disparate disciplines. The maps suggested for preparation in the figures are just that—suggested categories. It may be possible to combine data from one or more of these categories in a single map. The legends, in particular, should be revised and improved prior to actual mapping and as mapping proceeds. Table B1 is a rough estimate of the cost for preparing each map.

Research studies

94. In addition to the baseline data studies suggested for presentation on maps, a number of research studies involving specific geophysio-hydrologic facets of water resources planning in the Yazoo Basin are recommended.

95. Overbank storage of flood flows. Perhaps the most important and extensive of such studies would be a comprehensive inquiry into the conflict of interests regarding the use of the Yazoo Backwater Area for overbank storage of flood flows. (See the discussion in paragraphs 79-86 for some of the facets of this problem.) Such a study might conclude that future protection of the Yazoo Delta and of much of the lower valley from flooding depends on scrupulously maintaining the integrity of this and other such backwater sumps and, perhaps, to increase their size.

An interesting alternative to maintaining or increasing the size of the
backwater area in the southern part of the Yazoo Basin might be to increase the overbank storage between the main-line Mississippi levees along the basin's western border. This could be accomplished in small increments, when levee setbacks become necessary, for example. The study would attempt to balance the stringent flood-control requirements with economic and environmental requirements. Zoning of overbank storage areas for maximum use by agricultural, timber, industrial, and wildlife and fishing interests would be an important objective.

96. Although the study would be of considerable magnitude, the problem has been recognized as important by the Corps of Engineers for many years; and much has already been done toward arriving at viable answers. A multidisciplinary team of hydraulic engineers, civil engineers, civil engineers, biologists, geologists, agronomists, etc., should be able to devise a sound, comprehensive plan for future development of the overbank flood storage areas that border the Yazoo Basin on the south and west.

97. **Environmental succession studies.** The determination of trends of change is a principal requirement for defining management guidelines. To even a casual observer it is apparent that many areas within the Yazoo Basin are changing at a rapid rate and that, although many of these changes are the result of natural processes, the most striking and rapid occur as a result of human activities. Recognizing that these changes substantially affect the future use of the basin, it is most important to direct attention to what is occurring at a given place with time. One of the most successful tools to help predict changes and to develop guidelines that will direct changes toward the most useful ends is the environmental succession model. Selecting a fixed area and using geologic data, historic information, and present conditions, types and rates of change that are occurring in that area as a result of natural processes can be established. Extrapolation of this change is useful in postulating future conditions. This is the basic approach for defining and measuring geological succession and for predicting changes that result from this succession if allowed to continue uninterrupted.

98. In most instances, however, the natural succession is
disrupted by human impact and deviation occurs. By measuring this deviation in historic times through the use of maps and other historic documents, it is possible to predict future conditions for a modified succession that will be a measure of human impact. Figure B23 is a conceptual model of environmental succession with time. When natural succession is thought of as representing a condition of balance and modified succession some degree of imbalance, the condition associated with block D represents an environment that has moved farthest toward imbalance. With management considered, a compromise between natural succession and the condition resulting from undirected and uncoordinated human modification is possible. The objective of management, then, is the block shown as A or B.

99. It is suggested that four or five 25,000-acre plots be carefully selected within the Yazoo Basin for environmental succession studies: three within the Yazoo Delta, one within the Loess Bluffs, and one within the remaining uplands. Changes in landforms, hydrologic features, vegetation, topography, and related parameters within the past 1000 years should be considered. The situation 1000 years ago and 200 years ago would be postulated from geologic studies and historic accounts. The situation 100 years ago would be developed from historic accounts and maps. The most detailed studies would be made of three groups of available aerial photography spaced as far apart as possible from the standpoint of the dates the photographs were taken. Depending on the area involved, photographic coverage might be available for 1935, 1955, and 1975; and very useful extrapolations could then be made of conditions that might prevail in 1995. If postulated changes between 1975 and 1995 are substantially adverse, management alternatives would be considered that would cause the least environmental imbalance.

100. **Subsidence and general lowering of the Yazoo Delta surface.** In an area as flat as the Yazoo Delta, slight changes in surface elevation cause pronounced changes in drainage patterns that can markedly affect structures designed for flood control. A measure of the flatness of the delta is that for every 1-ft rise in river stage during floods, it is estimated that an additional 50,000 acres of delta land
Figure B23. Conceptual model of environmental succession
are inundated. Since the installation of the levees, much of the Yazoo Delta is protected from flood flows. The gradual, periodic increment of soil is no longer being added to the surface as floodwaters evaporate, transpire, or drain away following floods. Moreover, the amount of soil lost to erosion and wind attrition each year may be of some significance. It is estimated that cultivated areas lose 10 tons per acre per year to such attrition alone; and although much of this soil comes to rest again within the delta, some is lost.

101. The most important factor affecting surface elevations, however, is subsidence of the Recent deposits with time. The most pronounced subsidence occurs in the thick clayey backswamp and abandoned channel fill deposits, but densification of the sand and the gravelly deposits in the substratum also results in subsidence with time. With no addition of soil to the surface by flood flows, the overall lowering of the delta surface may eventually pose a significant problem. Added to natural subsidence is the increased compaction and the increased rate of compaction caused by withdrawal of groundwater from the substratum. At the present time, water tables within the delta are very near the surface, and withdrawal of water from this prolific sand and gravel aquifer has been insufficient to cause any marked cones of depression. However, increased use of this aquifer, particularly for rice and other high-water-consuming crops, will undoubtedly cause local water table depressions and the compaction and subsidence that accompanies large amounts of groundwater withdrawal.

102. A factor tending to increase surface elevations along the eastern borders of the delta is the introduction of sizeable amounts of sediment from the uplands. However, most of this sediment is carried downstream by the Yazoo River, and the overall rise in elevation of the alluvial aprons and of the delta surface at the base of the uplands is thought to be minimal. In general, it is conceded that although the eastern delta margins may have experienced some rise in elevation during the past century, by far the largest portion of the delta surface is subsiding.

103. The study proposed here will consider local increases in
elevation within the delta during the past century, but its major purpose is to determine the amount of overall lowering of the delta surface with time. It will also consider the factors affecting such lowering; the effect of increased groundwater withdrawal from the Recent substratum and from other deeper geologic aquifers; and the possible environmental, economic, and engineering hazards associated with this phenomenon.

104. Rates of erosion in the Loess Bluffs. The most intricately and tortuously dissected physiographic province of the Yazoo Basin is the Loess Bluffs, and relief in the loessial areas is as great as that of any soil area in the United States. Apparently this has not always been so. The first white settlers in the area often chose the loessial hills for homesites, not only because such sites were well above the floods that swept across the Yazoo Delta, but because there were large, relatively undissected flats that could be used for farming. Clearing the timber from such upland flats and cultivating them, however, immediately subjected the loess hill country to massive erosion (see discussion beginning in paragraph 36); and within an undetermined but very short period, erosion on a massive scale radically changed the topography of the area. The effect of this massive influx of sediment within a very short period of time into the creeks and rivers that drained the area must have been profound. The growth of the alluvial fans and aprons at the base of the bluffs must also have been significant.

105. Farming has all but ceased in the Loess Bluffs but increased occupation; grading for roads, subdivisions, and commercial sites; and above all, the exploitation of the extensive sand and gravel deposits that often lie beneath the loess have had a serious effect on the rates of erosion, and in turn, on sedimentation within the bluffs and in the Yazoo Delta flatland downstream. Moreover, abandoned gravel pits by the hundreds leave large barren gashes in the terrain. Sand and loessial silt sluiced from the gravel operations block drainageways and form barren, unfertile flats above once rich bottomland. And there is little doubt that exploration for and exploitation of these valuable sand and
elevation within the delta during the past century, but its major purpose is to determine the amount of overall lowering of the delta surface with time. It will also consider the factors affecting such lowering; the effect of increased groundwater withdrawal from the Recent substratum and from other deeper geologic aquifers; and the possible environmental, economic, and engineering hazards associated with this phenomenon.

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gravel deposits will continue and increase with time. Because many of
the best sites have already been found, future sites will have to contend
with ever-increasing overburdens of loess and fine sand that must be
disposed of and that will further aggravate a deplorable environmental
situation.

106. The proposed study should have the following among its ob-
jectives:

1. An inventory of all abandoned and operating gravel
pits in the Yazoo Basin (also needed for the baseline
map proposed in Figure B19).

2. An estimate of the most probable areas into which the
sand-and-gravel industry will expand and the thickness
of overburden that will have to be removed and disposed
of (also needed for the baseline map proposed in
Figure B16).

3. A reconstruction, if possible, of the natural topographic
situation in the Loess Bluffs prior to the advent of the
first agrarian settlers, and a development of the history
of erosion of the bluffs to the present time. This should
include an estimate of the volume of material eroded and
the changes in erosional rates with time. The resulting
sedimentation downstream into and through the Yazoo Delta
should be traced.

4. The development of a set of guidelines based on these
data to counteract the environmental impact of loessial
erosion and increased sand and gravel exploitation in the
Loess Bluffs.

107. Preservation of Yazoo Delta lakes. Some of the most esthe-
tically pleasing of the landforms of the Yazoo Delta are the many deep
lakes that resulted from neck or chute cutoffs of former river bends
or the abandonment of long segments of former river courses. Fringed
and often partially occupied by moss-clad forests, the lakes are sites
for state parks, vacation homes, water sports, fishing, and other recre-
reational benefits that add immeasurably to the cultural and economic
value of the Yazoo Basin. Sedimentation in these lakes prior to the
construction of the levees probably occurred at a relatively rapid
rate. Sedimentation since flood flows have been contained is probably
minimal. However, little that is definitive is known about these
sedimentation rates, and it is suggested that comparisons be made of available hydrographic data supplemented by borings in at least one major oxbow lake (or possibly one outside and one inside the levee) to establish as firmly as possible the present and past rates of filling of these water bodies.

108. Even though the levees have preserved these lakes from being rapidly silted in by flood flows and thus added to their life span, they have also prevented the periodic flood flows from flushing, rejuvenating, and purifying the water contained in these lakes. Eutrophication and pesticide poisoning have all but eliminated many of these lakes as a habitat for game and commercial fishing. A record of such pesticide poisoning is undoubtedly contained in the bottom sediments of many of these lakes. It is suggested that the study proposed here consider alternative methods of flushing or otherwise preserving these lakes for fishing. Such methods might involve a combination of aeration and chemical purification, or the pumping of fresh water into the lakes from nearby streams. An interesting possibility might be to channel the flow of rivers such as the Big Sunflower or the Yazoo through these lakes during bank-full stages. There are often elongate depressions leading from oxbow lakes toward the rivers of which they were once a part, and construction of channels and control structures that would route bank-full flows through the lake and back into the river for short periods of time might be a viable though admittedly costly option.

109. Another important part of the problem of preserving the Yazoo Delta lakes is the possible effect of lowering the water table. As more and more groundwater is withdrawn from the shallow substratum aquifer for agricultural purposes and as cones of depression are formed adjacent to the lakes, water from the lakes will tend to recharge the depleting aquifer. Little data exists at the present time as to whether this poses a significant threat or is of no consequence to the Yazoo Delta lakes.

Summary

110. The geologic development of the Yazoo Basin is discussed in
the first half of this Appendix and is a convenient framework on which to base the need for geologic, physiographic, and related hydrologic data pertinent to water resources management in the basin. It is concluded that such data can best be displayed on maps with accompanying charts, graphs, and tables.

111. Maps (suggested scale 1:250,000) with accompanying data sheets where relevant should be prepared as indicated in Figures B10-B14 and B16-B22. They would form part of a folio of maps that would inventory basic data needed for planning purposes. Map titles are:

1. Topography
2. Relief
3. Slope
4. Landforms
5. Pre-Quaternary geology
6. Quaternary geology
7. Soils and rock
8. Historical, archeological, and geological sites
9. Mineral resources
10. Groundwater
11. Drainage basins, lakes, and streams
12. Transportation net, powerlines, and pipelines

112. In addition, five research studies are recommended. Results would be published in separate reports or in the map folio suggested above.

a. **Overbank storage of flood flows.** A comprehensive inquiry regarding the maintenance or possible planned increase in size of the Yazoo Backwater Area and other areas bordering the Yazoo Basin for the accommodation of flood flows.

b. **Environmental succession studies.** Three areas are suggested for study in the Yazoo Delta, one within the Loess Bluffs, and one in the higher uplands. Types of change in natural processes, particularly those caused by human impact, are established from geologic data, historic information, and conditions portrayed on aerial photographs covering as wide a span of time as possible. Changes and rates of change are extrapolated for the future.

c. **Subsidence and general lowering of the Yazoo Delta Surface.** A study of subsidence and its possible environmental consequences within the Yazoo Delta. A general lowering of the land surface results from compaction, withdrawal of groundwater, erosion and wind attrition of cultivated areas, and the fact that the area no longer receives periodic increments of silt and clay from flood flows.
d. Rates of erosion in the Loess Bluffs. This study involves the development of the erosional history and a determination of erosional rates within the Loess Hills; an inventory of all abandoned and operating gravel pits in the Yazoo Basin, almost all of which are located within the loessial belt; and the development of guidelines to counteract loessial erosion and the environmental hazards associated with sand-and-gravel exploitation.

e. Preservation of Yazoo Delta Lakes. This study is aimed at determining the distribution, geometry, rates of filling, and methods of preserving the many oxbow and related lakes within the Yazoo Delta.
References


Table B1
Suggested Study Groups and Cost Estimates
for Preparation of Baseline Maps

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* Keyed to paragraph 92.
** Costs include data collection and preparation of maps and accompanying data sheets.
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TABLES C1-C5
CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

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<td>joules</td>
</tr>
<tr>
<td>Fahrenheit degrees</td>
<td>5/9</td>
<td>Celsius degrees or Kelvins*</td>
</tr>
</tbody>
</table>

* To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula: \( C = \frac{5}{9} (F - 32) \). To obtain Kelvin (K) readings, use: \( K = \frac{5}{9} (F - 32) + 273.15 \).
PART I: INTRODUCTION

1. The objectives of this appendix are to (1) identify problems relative to the chemical, physical, and hydrological characteristics of the Yazoo Basin; (2) identify data gaps; and (3) recommend studies and/or actions that will supply the data that are necessary for the U. S. Army Engineer District, Vicksburg (VXD) to make project action decisions in compliance with the U. S. Water Resource Council's "Principles and Standards for Water Resource Management."

2. This appendix presents the major environmental problems and discusses within three basic sections (Parts III, IV, and V), Climatology, Erosion and Sedimentation, and Water Resources, the actions and conditions that create the problems. Historical synopses are used to provide the setting for present basin conditions and the substance from which to make comparisons relative to the existing problems. Areas pertinent to the existing problems are discussed only to the extent needed for a basic understanding of the problem. VXD expressed the need for information on problems other than those related to flood control; however, certain suggestions within the realm of flood control are offered for consideration. The initial survey of literature and local, State, and Federal agencies revealed less urgent problems within the realms of groundwater and meteorological data; therefore, less discussion was devoted to these. This is not meant to imply that greater knowledge and technological advances within these areas would not contribute significantly.

3. Principal problems and the status of available data are summarized at the end of Parts III, IV, and V. Part VI presents the recommendations resulting from this study and indicates the priority given to each recommendation.
4. The drainage basin of the Yazoo River encompasses 13,355 square miles.* It is bordered on the north by the drainage divide of the Wolf and Hatchie River basins, on the east and south by the divide of the Tombigbee and Big Black River basins, and on the west by the Mississippi River. The Yazoo River is formed near Greenwood, Mississippi, by confluence of the Tallahatchie and Yalobusha Rivers. The Tallahatchie, in turn, is formed near Charleston, Mississippi, by confluence of the Little Tallahatchie and Coldwater Rivers. Steele Bayou and the Big Sunflower River are major tributaries that flow into the Yazoo River from the northwest near Vicksburg. Virtually all of the Yazoo Basin waters discharge into the Mississippi River via the Yazoo Canal at Vicksburg, Mississippi.

5. Two streams that are usually omitted in a discussion of the major Yazoo River tributaries, but that deserve consideration in order to complete the drainage picture, are Cassidy Bayou and Yocona River. The former is a western tributary of the Tallahatchie River, and the latter is an eastern tributary of the Little Tallahatchie River.

6. The major northeastern tributaries of the Yazoo River (Yalobusha, Yocona, Little Tallahatchie, and Coldwater Rivers) flow through several physiographic regions that contain different geological formations and different soil types (Figure C1). (Refer to Appendix B.) The remaining major tributaries lie entirely within and drain the Alluvial Plain. The Alluvial Plain, which is approximately 50 miles wide at the maximum, extends approximately 200 miles in a north-south direction from near Memphis, Tennessee, to Vicksburg, Mississippi. The topography of the Alluvial Plain ranges from flat to gently sloping with successive ridges and swells that once were stream borders. The drainage is in a general north-south direction, and stream slopes vary from 0.25 to 0.50 ft per mile.1

* A table of factors for converting U. S. customary units of measurement to metric (SI) units is found on page C3.
Figure C1. Physiographic regions of the Yazoo Basin
7. The Yazoo Basin Uplands exhibit a varied topography (Figure C1). The basic physiographic regions are, from west to east, the Loess Bluffs, North Central Hills, Flatwoods, and Pontotoc Ridge. The topography of the Yazoo Basin Uplands is characterized by rugged to rolling hills with valleys ranging from one-half to two miles wide.¹

8. The Loess Bluffs region is relatively narrow (about 15 miles wide) and borders the Alluvial Plain. The Loess Bluff region is characterized by steep hills, which often rise abruptly to more than 100 ft. Steep bluffs and deep, narrow hollows are found adjacent to the Alluvial Plain. The change from one physiographic province to another is not as abrupt within the Uplands as between the Alluvial Plain and the Uplands.

9. Four large Corps of Engineers flood-control reservoirs retard runoff waters from the north-central and eastern Uplands. Lakes at Grenada, Enid, Sardis, and Arkabutla collect waters of the Yalobusha, Yocona, Little Tallahatchie, and Coldwater Rivers, respectively. These reservoirs serve as settling basins by slowing the waters of the rivers. When released, the waters have a reduced sediment load and, therefore, have a greater erosive capacity. Streambed and bank erosion are, consequently, a problem below these reservoirs.

10. Upland stream flow is generally in an east-west direction and the average stream gradient is 1.5 ft/per mile.¹

11. The average annual precipitation in the Yazoo Basin is approximately 53 in. (Figure C3), and the average annual stream discharge is 17,700 cfs.²
PART III: CLIMATOLOGY

Precipitation

12. The National Weather Service, Jackson, Mississippi, collects precipitation data from 43 stations within the Yazoo Basin (Figure C2). Isopleths of annual precipitation norms constructed by the Weather Service using data collections from 1941 to 1970 show annual precipitation ranging from 50 in. throughout the western delta to 56 in. at Pontotoc in the north-eastern Uplands (Figure C3). Similar monthly norms show that approximately one-third of the total annual precipitation occurs in February, March, and April with peak occurrence of 6.4 in. in March throughout the drainage basin of Grenada Lake (Figures C4-C6, respectively). Minimal precipitation occurs in August, September, and October with October being driest for the basin and ranging from 2.4 to 2.8 in. (Figures C7-C9, respectively). The monthly isopleths for over a 30-year period range from a low of 2.4 in. in October to a high of 6.4 in. in March and show striking changes occurring on a seasonal basis. The normal annual precipitation isohyets show considerable differences in precipitation within the basin and conform more to topography than to latitude.

Temperatures, Air Masses, and Storms

13. Normal annual temperatures range from 61°F in the northeastern Uplands of the Yazoo Basin to 65°F at Vicksburg in the extreme southwestern part of the basin (Figure C10). The isotherms generally show an inland penetration of warmer air masses in the Alluvial Plain portion of the basin between the Mississippi River and the Loess Bluffs. A reverse of this trend occurs over the Loess Bluffs where cooler air masses appear to reach southward.

14. The Yazoo Basin is located in a region where warm air masses laden with moisture from the Gulf of Mexico meet with cooler continental air masses during winter and early spring, thus producing sudden large
Figure C2. Rainfall stations in the Yazoo Basin with subdivisions as used by the National Weather Service (courtesy of National Weather Service, Jackson, Mississippi)
Figure C3. Normal annual precipitation, inches, 1941-1970 (courtesy of National Weather Service, Jackson, Mississippi)
Figure C4. Normal precipitation, inches, for the month of February, 1941-1970 (courtesy of National Weather Service, Jackson, Mississippi)
Figure C5. Normal precipitation, inches, for the month of March, 1941-1970 (courtesy of National Weather Service, Jackson, Mississippi)
Figure C6. Normal precipitation, inches, for the month of April, 1941-1970 (courtesy of National Weather Service, Jackson, Mississippi)
Figure C7. Normal precipitation, inches, for the month of August, 1941-1970 (courtesy of National Weather Service, Jackson, Mississippi)
Figure C8. Normal precipitation, inches, for the month of September, 1941-1970 (courtesy of National Weather Service, Jackson, Mississippi)
Figure C9. Normal precipitation, inches, for the month of October, 1941-1970 (courtesy of National Weather Service, Jackson, Mississippi)
Figure C10. Normal annual temperature, °F, 1941-1970 (courtesy of National Weather Service, Jackson, Mississippi)
temperature changes and much precipitation during these seasons. It is not uncommon to see a $20^\circ F$ change in temperature from one 24-hr period to the next during this part of the year. Freezing weather, sleet, snow, and ice storms are not uncommon. The lowest temperature on record in the basin is $16^\circ F$ below zero at Batesville in February 1951. The highest number of days with $32^\circ F$ or lower is 60, on record for Panola County.

Wind storms and tornadoes frequently occur in February, March, and April.

15. From May to September, the basin is characterized by hot humid days and balmy nights. Some relief is provided by thunderstorms, which occur frequently and are often accompanied by violent local winds. The thunderstorms usually bring heavy rainfall over short periods. As much as 0.83 in. in 5 min is on record as having once fallen in Vicksburg.

16. Tropical cyclones, which occur from June to November, also affect the weather of the Yazoo Basin. The occurrence of the storms in September probably accounts for the higher precipitation in this month than occurs in August or October. Gales resulting from these weather disturbances are known in the basin as September gales due to their frequency of occurrence during this month. The gales are an economic setback to farmers in the basin due to their inopportune occurrence at harvesttime. Regardless of the gales that sometimes occur in the autumn, this is the most pleasant season in the basin as it is generally accompanied by warm days, cool nights, and relatively low humidity.

17. Although sleet, snow, and freezing weather occur in the basin, such occurrences are normally of very short duration, and outdoor sports can be pursued the year round. The most accurate statement concerning winter weather in the Yazoo Basin is that frequent and sudden changes are common.

18. A brief summary of the climate of the State of Mississippi by the Weather Bureau, U. S. Department of Commerce, states that "Mississippi has a climate characterized by absence of severe cold in winter and extreme heat in summer; that the ground rarely freezes and outdoor activities are generally favored year-round; cold spells are usually of short duration and dry spells most frequently come at harvest-time when needed most." While this quote is for the entire state, it
is also applicable to the Yazoo Basin.

Principal Problems

19. One of the principal problems in the basin is to predict weather events with sufficient advance time to prepare for the effects of such events.

Status of Available Data

20. The primary source of climatological data is the Environmental Data Service of the National Climatic Center, U. S. Department of Commerce, National Oceanic and Atmospheric Administration. The National Weather Service at Jackson, Mississippi, maintains limited records of climatological data for the Yazoo Basin.

21. Daily records of air temperature and precipitation for each station are compiled into monthly means and departures from normal and are published yearly as a part of an annual summary of climatological data. Other parts of the summary include monthly total precipitation and departures from normal, temperature extremes and freeze data, soil temperatures, and total evaporation and wind movement. Soil temperature, total evaporation, and wind movement are measured at only a few stations. Other data are areally and serially comprehensive.
PART IV: EROSION AND SEDIMENTATION

21. An interpretation of erosion and sedimentation problems within the Yazoo Basin requires a basic understanding of land use practices that occur as well as the types of soil involved and their erodibility. The reader is referred to an excellent discussion of soil types, soil formation, and the erodibility of soils within the physiographic regions of the basin presented in Appendix B, "Geology and Physiography of the Yazoo Basin."

Land Use Capabilities

22. Knowledge of soil properties is quite well advanced, and the locations of and proper management practices for the various soils of the Yazoo Basin are known. In general, land management practices that are good for the soil are also good for the quality of the environment. Since the quality of the environment is not benefited from all of the land management practices presently being employed throughout the Yazoo Basin, it is fair to suggest that this knowledge is not being fully used.

23. Historically, land use in the Yazoo Basin has been dominated by cotton farming with sufficient small grain, corn, and hay to supply the farmer with livestock feed. Following the Civil War, most of the plantations in the Uplands region of the basin were broken into small farms due to economic conditions and the loss of slave labor. A sharecropping system arose whereby former slaves worked portions of old plantation in return for a share of the crop. In other cases the land was rented to individuals who were thrifty enough to gain possession of a pair of mules and plow tools; these sharecroppers were usually supplied with land for gardening and keeping cows, hogs, and chickens for their own consumption without charge by the landowner. This same system was practiced throughout the South. While the sharecropping system was practiced both in the Alluvial Plain and in the Uplands region, the rich flatlands of the Alluvial Plain were more conducive to greater returns and enabled farmers to retain larger tracts of land. Land productivity
and topography were, therefore, responsible for the evolution of two rather different cultures between the Alluvial Plain and Uplands.

24. The system of sharecropping continued through World War II, but it began to be supplanted following the arrival and dissemination of the farm tractor and its ancillary land-breaking and tilling equipment in the basin. The advent of tractors somewhat reduced the need for farm labor. With the arrival of mechanical cotton pickers and herbicides, the need for farm laborers was greatly reduced. While the need for common farm labor was being reduced, cost of production was rising. The new equipment required large capital investments and a more skilled labor pool for operation. Almost simultaneously with the advent of chemical weed control came passage of the Minimum Wage Law, which also applied to farm laborers. Thus, the cost benefits of the mechanized operations and reduced amount of common labor were offset by increased costs of operation.

25. The rising sale price of soybeans together with the minimal cost of production became very attractive to planters. Soybeans grow and produce well on lands that are normally either unsuitable or marginal cotton lands. Cotton production had long been supplemented by soybean production on the lowlands; but with the greater demand and unprecedented high prices of soybeans, accompanied by increasing production cost of cotton, many of the lands formerly planted in cotton were shifted to soybeans. Profits from soybeans together with the drainage of lowlands has also resulted in the clearing of much of the land. As a result of the economic factors, soybean production in the basin has supplanted cotton production as king.

26. In the early 1950's, rice production began in the basin and has now become widespread in the upper and middle Alluvial Plain due to favorable climate, land, water supply, and economics. These factors accompanied by removal of allotment restrictions are likely to cause a further increase in the acreage planted with rice. Soybeans, cotton, and small grains (predominantly rice) are virtually the only agricultural crops grown in the Alluvial Plain. Timber, especially cottonwood,
production in the southern portion is considerable. Virtually all of the forest remaining in the Yazoo Alluvial Plain is located in unprotected floodprone areas or in the national forests.

27. The development of these patterns of agriculture have an important bearing not only upon the problems of erosion and sedimentation, but also on the problems of chemical pollution and eutrophication. This relationship with the latter two problems will become apparent in the discussion of Water Resources in Part V.

**Erosion**

28. According to Shindala and Priest, "the ability of any fluid stream to move sediment particles depends on the physical properties of the sediment particles, the physical properties of the fluid, and the relative velocity of the fluid with respect to the particles." The total sediment load of a stream is the sum of the bed load and suspended load. In a broader sense, a particular natural stream is said to have a certain sediment-carrying capacity. If at any time the stream is carrying less than its capacity, it will tend to scour (erode) its boundary. If carrying more than its capacity, it will deposit part of its load. The erosive capability of an initially uniform fluid such as clean rainfall can be assessed based upon runoff velocity and the physical properties of materials over or around which the water flows. However, once the water has passed over an erodible material, the ability to cause further erosion is decreased by the load being carried. The widespread gully erosion that has occurred in the Loess Bluff region of the basin exemplifies the effects of high-velocity runoff coupled with passage over a soil whose physical properties are conducive to erosion. Perhaps because of the very obvious hillside erosion, man has been too prone to equate erosion with water velocity with disregard for the other criteria.

29. While erosion has long been recognized as a major problem in the Uplands of the Yazoo Basin, little attention has been given this matter, other than to streambanks, in the Alluvial Plain. While gully
erosion in the Uplands has been very obvious and widespread as man
cleared and cultivated the land, sheet erosion occurring in the rela-
tively flat, deep soils of the Alluvial Plain was thought to be negligi-
ble. The U. S. Department of Agriculture (USDA) Soil Conservation
Service (SCS) estimate of over 100 million gross tons annually of sedi-
ment moved from the hills into the Alluvial Plain during the 1930's is
an overwhelming figure. 2 Illustrating this point is the fact that the
USDA Agriculture Research Service (ARS) Sedimentation Laboratory has had
comprehensive watershed studies (Pigeon Roost Creek Watershed) in prog-
ress in the Yazoo Basin Uplands since 1957, yet it was 1972 before water-
shed studies were initiated in the Alluvial Plain (Friars Point
Watershed) by the same agency. Also the SCS June 1975 estimate of
average annual gross erosion was 86 tons per square mile for the Alluvial
Plain; whereas preliminary studies at Friars Point Watershed indicate
that sheet erosion is occurring at the rate of 3,840 tons per square
mile annually.* The present SCS estimate of 27,819,105 gross tons an-
nually from the Uplands 2 is comparable with the 25,579,200 gross tons
of sheet erosion calculated with ARS Sedimentation Laboratory preliminary
data for an approximately equal area in the Alluvial Plain. Indicative
of this large amount of erosion is the rapid siltation of ditches, lakes,
and other water pooling areas within the Alluvial Plain, where silt is
deposited as the water velocity is reduced.

30. While improved land management practices such as reforesta-
tion and the construction of large and small reservoirs, lakes, and farm
ponds have reduced erosion from over 100 million tons in the Yazoo
Uplands during the 1930's and early 1940's to an estimated
27,800,000 tons in 1970, it is safe to say that the total erosion in the
Alluvial Plain is now increasing due to land clearing, drainage prac-
tices, clean tilling, and autumn and winter land fallowing practices.
In the Yazoo Uplands, emphasis has been placed on reducing the velocity
and thus the kinetic energy of the moving water; in the Alluvial Plain,

* A. J. Bowie, ARS Sedimentation Laboratory, Oxford, Miss., personal
communication, 24 Sep 1975.
the emphasis has been on getting water off of as much land as possible as rapidly as possible. Rivers, bayous, and creeks have been cleared and snagged and in many cases have had their channels shortened and leveed. This construction tends to maintain higher energies in the more rapidly moving surface waters. A major effect of rapid drainage is that the total sediment load capacity of the water is greater, and thus a greater amount of erosion is induced. During low-water periods, some of the effects of erosion in the Alluvial Plain are readily observable in the form of sediment accumulation at the mouth of drainage ditches (Figure C11). Where the ditches discharge into lakes, larger ditches, canals, or other streams, coarse particles are deposited. Farther out into the main stream where the water has lost much of its velocity, a miniature delta of fine particles forms.

Accretion versus erosion

31. The frequent occurrence of floods has had an important role in the land-building processes that have occurred in the past within the Yazoo Alluvial Plain. Slowly receding floodwaters build land by depositing their loads of sand, silt, and clay. Until the historical period (advent of Europeans into the area), very little erosion occurred, since there was lush vegetation and ground cover in the area to bind the soil and reduce the energy associated with rainfall and runoff. The kinetic energy associated with rainfall can be quite significant. Based upon an average rainfall velocity of 21.16 fps calculated by U. S. Army Engineer Waterways Experiment Station personnel from data supplied by the U. S. Weather Service, Jackson, Mississippi, the kinetic energy possessed by 50 in. of rainfall amounts to $7.8 \times 10^7$ ft-lb per acre per year. As Alluvial Plain streams were channelized and leveed and the land cleared and tilled, the predominantly land-building process changed to a subtle, but apparently widespread, erosional process. Where the land floods, land building still occurs but in the same areas as erosion. If sufficient ground cover is not present, then it is likely, but unverified, that erosion exceeds land building, especially where flooding is infrequent. In the lower Alluvial backwater area that is still forested and still subjected to frequent flooding it is safe to
Figure C11. Sediment accumulation at the mouth of a drainage ditch in the Yazoo Basin, Issaquena County, Mississippi, December 1975

Figure C12. Sand and silt in the Yalobusha River, Calhoun County, Mississippi, December 1975
assume that land accretion exceeds soil erosion. Where the land is cleared in this backwater area, there are insufficient data to make a valid assumption since during most of the year the land is washed by relatively clean rainwater.

**Channel and streambank erosion**

32. Straight channels paralleling land slope produce the maximum kinetic energy in flowing waters. The interaction of the flowing waters with the boundaries of the channel produces bank erosion and channel degradation in proportion to the kinetic energy of the water, the excess carrying capacity of the water, and the physical properties of the boundaries. The physical properties of the natural or man-made boundaries are seldom uniform over a long stretch of stream; thus different degrees of erosion, even over a uniform gradient, are observed. Energy dissipation of moving waters is accomplished against some form of resistance. Therefore all hydraulic computations involving flow in open channels require an evaluation of the roughness characteristics of the channel to provide a resistance coefficient. Data collections by the ARS Sedimentation Laboratory from a small natural channel in the Pigeon Roost Creek Watershed show that the resistance coefficients change considerably as a runoff event progresses.\(^5\) Data from the watershed also indicate that erosion rates for natural undredged channels vary from 10 to 44 percent of the total watershed measured sediment and that as much as 1700 tons per inch of runoff per channel mile per year occurred in a recently dredged channel. In this dredged channel, bank erosion accounted for 52 percent of the total erosion.

**Sedimentation**

**Streambeds**

33. Sedimentation in streambeds presents a major problem in the Yazoo Basin. This is especially true in recently constructed channels above large reservoirs and in certain channels in the Alluvial Plain that are adjacent to the Loess Bluffs. Examples of this problem are exhibited by sand and silt sediments in the Yalobusha (Figure C12) and
Schuna Rivers above Grenada Lake. These streams were channelized in the late 1960's and are now being considered for redredging. The Big Sand Diversion Channel that was opened during the 1973 flood is also an example (Figure C13). The channel that was once 11 ft deep is presently filled with sand.

34. An example of mid-Alluvial Plain channel sedimentation was provided by Mr. P. B. Simpson of the Belzoni Drainage District.* The district comprises 160 miles of ditches that drain 90,000 acres. Frequency of cleaning the ditches averages once every 10 years and an average cut is 18 in., giving an average annual siltation rate of 1.8 in. Mr. Simpson said that in his earlier years the "gumbo land" (clay soil) gave them very little trouble but that in recent years it has also become a problem. This is probably as the result of deeper and more frequent tillage of more acres of this type of land.

Reservoirs

35. The sedimentation rates for the four north Mississippi reservoirs, Arkabutla, Sardis, Enid, and Grenada Lakes, are reported in Reference 6 for calendar year 1966. The average annual deposit in acre-feet per square mile is tabulated as follows: Arkabutla, 622; Sardis, 647; Enid, 558; and Grenada, 1205. Factors that influence these rates include the ratio of reservoir to drainage area acreages, slope of drainage area, land cover of drainage area, soil type of drainage area, reservoir water-retention time, turbulence of reservoir waters, and particle size of suspended materials. Researchers must consider these variables to arrive at a rational explanation for differences in sedimentation rates of the reservoirs. Considerable research involving these variables would be necessary in order to explain completely the differences in rates of sedimentation in these reservoirs.

* P. B. Simpson, Belzoni Drainage District Engineer, Belzoni, Miss., personal communication, 11 Nov 1975.
Figure C13. Big Sand Diversion Canal, Leflore County, Mississippi, December 1975

Figure C14. Erosion produced by land fallowing adjacent to Bee Lake, Holmes County, Mississippi, December 1975
Future Outlook

36. Erosion and sedimentation have long been recognized as major problems in the Yazoo Basin. While many control practices have been employed in the Uplands, erosion in the Alluvial Plain has been considered of no significance and little effort has been expended to control it. Fall fallowing, a farm practice that encourages extensive sheet erosion, is being widely employed in this region in an attempt to reduce overwintering insects. Figure C14 is an example of gully erosion occurring in the Alluvial Plain as a result of fall fallowing on an incline and near the water line. This photograph was made on 13 December 1975, illustrating that erosion occurs not only in the spring season but throughout the year. Results of field trials of minimum tillage practices that would aid considerably in reducing soil erosion throughout all seasons are promising. These practices are proving economical and are being lauded by farmers who have employed them; thus, minimum tillage has a good chance of becoming widely accepted by farmers if other factors do not make it impractical.

Principal Problems

37. Based upon presently available information and data, the following are major problems existing in the Yazoo Basin:

a. Sheet erosion, especially on agricultural croplands. This erosion results in the loss of topsoil; the transfer of pesticides, organic materials associated with crop residue, and nutrients to surface waters; and an increase in turbidity of surface water. These impacts on surface water are discussed in more detail in Part V.

b. Channel and streambank erosion, especially in the Uplands.

c. Gully erosion in both the Uplands and the Alluvial Plain regions. This is particularly prevalent along drainage ditches with steep grades at points where one drainage ditch discharges into another, and where land is tilled on inclines. Gully erosion is also increasing in the Uplands where clear-cut forestry is practiced and in the Little Tallahatchie area where reforested lands have been cleared for pasture.
d. Sedimentation in channelized streams, above major flood-control reservoirs, and in the Alluvial Plain adjacent to the Loess Bluffs.

38. Rapid sedimentation in lakes and streams of the Alluvial Plain appears to be a problem; however, insufficient data are available to support this contention. Further investigation of such sedimentation is warranted.

Status of Available Data

39. The ARS Sedimentation Laboratory, Oxford, Mississippi, and the SCS, Jackson, Mississippi, are the primary sources of recent data for erosion and sedimentation in the Yazoo Basin.

Uplands

40. Comprehensive data that can be applied to Upland watersheds exist for the Sedimentation Laboratory's Pigeon Roost Creek Watershed. Much of these data has been synthesized and the remainder is undergoing synthesis. The references summarizing these data are listed in the Bibliography in a separate section entitled "Erosion and Sedimentation." Additional data are stored on computer tape at the Sedimentation Laboratory, Oxford, Mississippi. Sedimentation rates in the four U. S. Army Corps of Engineers flood-control reservoirs are documented in Reference 6.

Alluvial Plain

41. Very little data are available on erosion and sedimentation in the Alluvial Plain. The ARS Sedimentation Laboratory has data from their Friars Point Watershed Station, established in 1972, but the data are in raw unpublished form. VXD has little data on sedimentation in streams of the Alluvial Plain region. The data include some old surveys, some recent isolated studies on the Yazoo River above Yazoo City, and a recent study at the Swan Lake area. There are no data available on sedimentation in lakes of the Alluvial Plain.

42. The Mississippi Game and Fish Commission has data on pesticides (chlorinated hydrocarbons) in lake sediments in the Alluvial Plain,\textsuperscript{8,9}
and the VXD has similar data from the Ascalmore Creek-Tippo Bayou area. The only work containing both sediment rate and analysis is that from the Friars' Point Watershed, and this is not yet available in published form.

43. Due to lack of data, it was necessary to identify problems by personal experience and personal communications with agencies and individuals having experience in the Alluvial Plain.
PART V: WATER RESOURCES

44. Both groundwater and surface water resources of the Yazoo Basin are discussed within this section. Emphasis is placed on pollu­tional status and the discussion is restricted to the more obvious problems of pollution occurring within the basin.

Groundwater

45. According to the Mississippi Board of Water Commissioners, "the groundwater hydrology of the State is understood to the degree that the resources may be evaluated, the changes resulting from groundwater use recognized and interpreted, and the effects of future utilization of groundwater predicted." All portions of the Yazoo Basin are supplied with from two to five aquifers that supply the basin's needs. The Board indicates, however, that certain problems do exist, such as the inability of certain aquifers to transmit enough water at specified places, inadequate water systems, naturally occurring saline waters, and the possibility of contamination from oil production. Specific problems cited by the Board are low-yielding aquifers at considerable depths in parts of Calhoun, Lafayette, and Webster Counties and marked regional declines in the Sparta Sands and the Meridian Sand in northwestern Mississippi. The opinion of the Board is that a study of the Alluvial Plain aquifer is needed to determine how much water the aquifer can provide on a long-term basis in light of widespread heavy use for irrigation and industry.

46. An abundance of relatively clean groundwater is one of the Yazoo Basin's greatest assets. Recharge areas for the aquifers should be located and managed to provide maximum recharge with clean water. Petroleum and other drilling and/or pumping operations should provide maximum precautions to prevent contamination of groundwaters from such operations.
Surface Water

Flood control

47. Since the Flood Control Act of 15 May 1928, the Corps of Engineers has completed many flood-control structures (levees, reservoirs, and drainage ditches) throughout the Yazoo Basin. These structures have reduced the severity of flooding in the basin; however, the flood of 1973 made it clear that much remained to be done to provide adequate protection from extreme floods. The 1973 flood inundated 1,711,350 acres of land in the Yazoo Basin. Reference 13 states that 3,091,000 acres behind the levee in the Yazoo Basin were fully protected and 1,181,000 acres were partially protected. All of the partially protected lands plus 530,350 acres of so-called fully protected lands were inundated by the 1973 flood. The Corps estimates that without the flood-control projects, 4,879,500 acres in Mississippi would have flooded, whereas with these projects, flooding was limited to 2,381,820 acres in the state. The severity of flooding was substantially reduced by Corps works since there was no breach of the Mississippi Main Stem Levee; however, present Corps structures are inadequate to provide full protection from severe floods, such as occurred during the winter and spring of 1973.

48. Comprehensive data on flooding in the Yazoo Basin have been maintained since 1928 by the U. S. Army Engineer Division, Lower Mississippi Valley; the VXD; and the Office, Chief of Engineers. Virtually all flooding data within the basin are derived from these sources. VXD maintains and operates a series of gaging and discharge stations on the Yazoo River and its major tributaries at selected sites (Figure C15). Daily stage readings are normally taken from these stations, and weekly to biweekly discharges are measured. These readings are compiled annually in a District publication. These data are invaluable to the Corps in its effort to predict and control flooding in the Yazoo Basin.

49. Since the Corps, especially VXD, has a long and enviable record in flood fighting and flood control, it would be presumptuous
to suppose that their methods and techniques could be greatly improved. It might be suggested, however, that VXD consider the feasibility of applying some of the methods used in the Uplands to the Alluvial Plain. It has been shown by Broadfoot that certain delta hardwoods benefit from being flooded with rainwater until July; and while the remaining delta hardwood stands are limited, they do provide some storage acreage. There are approximately 66,000 surface acres of lakes in the delta, many of which might lend themselves to storage of excess water with modifications that might also prove to be ecologically sound. Present farm practices encourage rapid runoff and contribute to erosion and flooding in the lower delta. It might be well to reconsider whether rapid runoff of surface waters from farmlands in the Alluvial Plain is the most economically and environmentally sound practice. Certain other practices might increase groundwater, reduce flooding in the lower areas, increase soil fertility, and decrease soil erosion.

50. There are low areas throughout the Alluvial Plain area that are bounded by swells (terraces); these could serve as gated catchment basins in which rainwater could be stored in winter and early spring. When the Mississippi River waters begin to recede in the lower basin, the stored water could be released. With adequate drainage outlets, farmers would experience little delay in getting crops planted, and any delay would be somewhat compensated by having additional soil moisture available during dry summers. Storage of the runoff during rainstorms would allow for sedimentation of suspended materials; thus, materials that are eroded from higher areas would be used locally for land accretion, and soil fertility would be increased.

51. Many lakes currently serve very little purpose other than as agricultural runoff catchment basins, and their storage capacity is limited. The storage capacity of these lakes could be increased by providing adequate slopes for drainage. This would allow drawdown prior to the flooding season and storage during the flooding season. Flushing of stored waters might improve the environmental quality of the lake by removing some of the bottom sediments that frequently contain high levels of pesticides.
Figure C15 is a folded sheet at the back of this appendix.

Figure C15. Streamflow stations and gages, VXD, 1974
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Sources of pollutants

52. Pollutants are generally classified as toxic or nontoxic, organic or inorganic, and biodegradable or nonbiodegradable. Pollution studies must first identify the pollutant and then trace it to its source in order to eliminate or reduce continued pollution by a particular substance.

53. For discussions of environmental pollution, it is conventional and convenient to classify the sources of pollution as point and nonpoint sources. A point source of pollution is easier to deal with than a nonpoint source; consequently, more has been accomplished with point sources. While the Nation must continue its vigilance toward point source pollution, a major thrust in control of nonpoint source pollution is necessary if the Nation is to reduce environmental pollution to levels compatible with suitable environmental conditions.

54. Point source. The greatest volume of point source pollution originates from municipal and industrial waste. The Yazoo Basin occupies an enviable position with respect to point source pollution when compared with more populated portions of the Nation. This position stems not from any advanced pollution abatement programs but from a smaller population and a lower concentration of industries. SCS lists 84 industries in or near 27 communities within the basin. These industries are all classified as producing biodegradable waste. The basic commercial products produced are food and kindred products (73 percent of total industries in the basin), chemical and allied products (20 percent), paper and allied products (4 percent), petroleum and coal products (2 percent), and rubber and plastics products (1 percent). The largest centers of organic waste production are Vicksburg, Yazoo City, and Greenville. The SCS report also states that the population served by sewered communities in 1970 numbered 258,200, and total raw waste was 46,480 lb per day of biochemical oxygen demand. Average municipal sewage treatment for communities in the basin was estimated to be 50 percent. Techniques for locating and abating point-source pollution are available; point-source pollution is not presently a major problem within the VXD.

55. Nonpoint source. Nonpoint (diffuse) sources of pollution exist
throughout the Yazoo Basin and create much more serious problems than point sources. These pollutants enter the waters and sediments of the Yazoo Basin by way of two primary sources—the atmosphere and runoff waters.

Air pollution

56. The Mississippi Air and Water Pollution Control Commission operates six air-quality monitoring stations in the Yazoo Basin. Stations at Clarksdale, Greenwood, and Ripley measure the total suspended particles (TSP) once every 6 days; stations at Greenville and Vicksburg measure TSP and sulfur dioxide (SO₂) once every 6 days; and a station at Hernando monitors TSP, SO₂, soiling index, and ozone (O₃) on a continuous basis. Agricultural chemicals such as insecticides and herbicides are not monitored by the Commission. Certain studies conducted by the Biochemistry Department, Mississippi State University,¹⁶⁻¹⁸ and a study on pesticide residues in pond-raised fish¹⁹ indicate, however, that there is a significant amount of pesticide residues transported via the air during periods of the year that coincide with periods of local pesticide applications (spring and summer).

Water pollution

57. Historically, waters of the Alluvial Plain region have been far more productive than those of the Yazoo Uplands. During the 1930's and 1940's, the many lakes, bayous, and rivers of the region were noted for their fish production. Catfish and buffalo were for sale at the many small towns and hamlets adjacent to the lakes and streams, and numerous commercial fishermen lived in shacks along the stream and lake banks.

58. The late 1940's and the following years saw much land drained, cleared, plowed, heavily fertilized, planted to cotton or soybeans, and sprayed with various insecticides throughout the growing and fruiting seasons. Drainage projects coupled with the advent of massive tractors and land-breaking and tilling equipment made it possible for farmers to cultivate marginal land or land that had been previously subjected to seasonal flooding. The increasing demand for and the high price of soybeans and the low price of swampland enticed speculators and farmers.
alike to clear much land previously considered worthless as farmlands. This clearing and planting of lands to the water's edge was accompanied by greatly increased siltation, eutrophication, and pesticide pollution of the water of the Alluvial Plain.

59. Eutrophication. Eutrophication is the aging process of lakes and sluggish streams. Symptoms of eutrophication are fairly well recognized and include the increased availability of plant nutrients such as nitrogen and phosphorus, increased algal blooms, shifts from clean shorelines to floating bogs, and eventually the filling of the lake or stream.

60. Eutrophication is a natural process that begins when lakes or other standing or quasi-lotic bodies of water are formed and normally proceeds slowly under natural conditions. However, cultural development along shorelines and the production of organic wastes accompanying this development greatly accelerate eutrophication. The decomposition of organic wastes that are deposited in bodies of water results in increased levels of nitrogen and phosphorus. Nitrogen and phosphorus stimulate the production of both rooted aquatic plants and algae. Heavy algal blooms and the decomposition of plant materials that follow can result in immediate water-quality problems such as depressed oxygen levels. Long-term problems result from accelerated aging of the water body. Organic materials accumulate, fill in the water body, and eventually convert it to a bog and finally dry land.

61. Studies by McGaha and Millican on the four North Mississippi flood-control reservoirs show low nitrogen and phosphorus contents, low pH and bicarbonates, no carbonates, and generally low primary productivity. These reservoir waters are indicative of most of the Upland waters of the Yazoo Basin.

62. There is presently no information on the primary productivity or status of eutrophication for the waters of the Alluvial Plain. Heavy algal blooms that appear to be common in the standing waters of the Alluvial Plain indicate, however, that primary production may be much higher in this area than in the Upland. The heavy use of fertilizers and the principal problems of erosion and sedimentation indicate that
there is a potential problem of eutrophication in the Alluvial Plain that is in need of investigation.

63. Suspended sediment. Erosion and sedimentation are major problems in the Yazoo Basin and were discussed in Part IV of this appendix. A product of the extensive erosion that occurs in the basin is the high levels of turbidity caused by suspended particles that occur in the streams and standing waters of the basin. The suspended particles are generally composed of soil particles and organic debris. Turbidity can reduce light penetration in the water column and thus reduce primary productivity. Suspended particles are deleterious to aquatic animals because the particles interfere with respiratory processes and cause mechanical injury to the soft parts of sensitive or fragile organisms. Upon sedimentation they destroy nesting sites of fish and alter habitats for benthic fauna and flora.

64. Information and data that are necessary to determine the significance of these effects are not presently available for the Yazoo Basin. The most profitable avenue of research would probably involve a combination of investigations of erosion and sedimentation with alteration of habitat types.

65. Another problem associated with suspended particles is their role in the transport of agricultural chemicals, primarily pesticides, from the cotton and soybean fields of the basin to the surface waters. Many of the long-life pesticides are chlorinated hydrocarbons, which have very low water solubilities. These chlorinated hydrocarbons become attached to soil particles and are transported along with the particles when erosion occurs. 21

66. Pesticides. Populations of fish that have had long exposures to pesticides may become quite tolerant. The resistance of fish from the Alluvial Plain of the Yazoo Basin to DDT was first demonstrated in 1963. 22 Other investigators have since demonstrated similar tolerance and cross-tolerance of several species of fishes from wide-ranging locations within the Alluvial Plain. 24-27 This development of tolerance can result in the elevation of pesticide levels in tissue without killing the fish and is an important consideration relative to species that may
be consumed by man and other predators.

67. Bingham found that fish flesh, sediments, and waters of Wolf Lake (Alluvial Plain) were highly contaminated with DDT and toxaphene (Table C1). The mean level of DDT and its metabolites was 5.04 ppb (sample standard deviation $s = 1.34$), and that of toxaphene was 6.69 ppb ($s = 2.23$) for the flesh of bluegills taken from Wolf Lake (Bingham, unpublished data). During and shortly after treatment of adjacent cotton fields with methyl parathion the waters of Wolf Lake contained high amounts of this insecticide (Table C2); however, none was detectable in fish flesh and sediments. The concentrations of DDT and toxaphene in fish flesh and sediments were approximately 1000 times greater than in the water column. Insecticide concentrations in the water column appeared to vary directly with the turbidity.

68. Studies on Mossy Lake, in the Alluvial Plain, revealed low levels of DDT, toxaphene, and parathion (Table C3 and C4). Measurable insecticide levels appeared infrequently in sediments from a station near the mouth of a drainage ditch that was overgrown with grasses. After the ditch was cleared with a dragline, noticeable amounts of DDT and toxaphene began to appear in samples taken from this station. The clearance of the ditch apparently increased the flow velocity of the runoff, allowing greater amounts of sediment from adjacent cotton fields to reach the lake before settling. Chlorinated hydrocarbons are known to volatilize, especially when wet, and to be adsorbed by plants. DDT and toxaphene are hydrophobic, and it is likely that these pesticides precipitated and sorbed to the grasses before the ditch was cleared. Continued sampling on Mossy Lake by the Mississippi Game and Fish Commission in later years showed sufficient insecticide residue accumulation to induce the Commission to ban this lake, along with Wolf Lake and Lake Washington, from commercial fishing.

69. Insecticide contamination also appears to exist in Steele Bayou and the Yazoo, Little Sunflower, and Big Sunflower Rivers. A random survey of 20 lakes in the Alluvial Plain by the Mississippi Game and Fish Commission revealed additional evidence of widespread insecticide pollution. Further studies of various lakes and streams
by the Mississippi Game and Fish Commission\textsuperscript{29} and by the Gulf South Research Institute\textsuperscript{30} show widespread pollution of Alluvial Plain waters by insecticides and an apparent increasing concentration of certain insecticides in fish flesh with time.\textsuperscript{31} In a survey of 82 samples of fish from 19 lakes by Herring and Cotton, fish flesh from 11 lakes was found to contain insecticide residues in excess of maximum permissible USDA levels for human consumption.\textsuperscript{31} Recent investigations by the Mississippi Game and Fish Commission indicate that insecticide residue accumulation in fish tissues may be becoming a problem in the four large Corps reservoirs in the Upland area of the basin.\textsuperscript{32} The headwater bottomlands of these reservoirs are rather extensively farmed and contribute considerable amounts of sediment to the reservoir systems.

70. Insecticide sales in Mississippi over the past 5 years indicate a heavy use of methyl parathion and toxaphene (Table C5). The vast majority of these insecticides are used on cottonfields in the Yazoo Basin. Bass and other carnivorous fish populations of Alluvial Plain lakes such as Wolf Lake have either been eliminated or drastically reduced in number while forage fish contain high levels of these insecticides. The reduction in numbers of carnivorous fish, especially bass, in the lakes possibly results from the biological magnification of chlorinated hydrocarbons resulting in death of individuals and/or lower rates of reproduction.

71. The translocation of soils, agricultural toxicants, and nutrients from initial and target areas to new and undesired locations where they may have significant impacts on the aquatic systems needs thorough investigation. Practices that encourage the translocation need to be replaced by more conservative practices. Although widespread insecticide pollution of the waters and aquatic biota of the Alluvial Plain has been established and certain modes of insecticide transport implicated, the ratios of insecticides entering surface waters via air transport to those entering via rainfall runoff need to be identified and documented.

72. Effects of future technological advances. Agricultural entomologists have for a number of years been seeking other insect controls
to supplement and hopefully supplant the chemical insecticides that accumulate in the environment. Some successful experiments have indicated that biological methods of control are available. In recent field experiments, hexane was evaporated into the air of cottonfields continuously throughout the growing season to disrupt premating pheromonal communication between males and females of the pink bollworm. This treatment reduced infestation in bolls as much as commercial applications of insecticides. According to Mitchell, the time seems near when disruptants of pheromonal communication can be selected, formulated, and used in programs to control a large number of insect pests in a variety of situations including fields, vegetable crops, orchards, and pastures.

73. Graham gives a discussion of biological warfare on insects conducted by the USDA entomologists that show promise in controlling the cereal leaf beetle and the tobacco budworm. G. A. Niles lauds progress in developing cotton varieties that reduce egg oviposition by boll weevils, bollworms, and tobacco budworms.

74. Two innovative approaches for weed control are in their developmental stages. Research by Drs. M. G. Merkle, Jr., R. Wayland, and F. S. Davis, Professors in Soil and Crop Sciences, Physics, and Range Science, respectively, at Texas A&M University on the use of microwaves to prevent the germination of weed seed has resulted in the patenting of a device called the "Zapper." The Zapper, produced by the Phytox Corporation, appears promising. Weed control is claimed for up to 12 months, and certain crop yields have shown rather dramatic increases over chemical treatment. The treatment also appears to kill nematodes, algae, and certain insect eggs and larvae.

75. Another innovation in weed control employs an electrical discharge system. Developed and patented by Gerald W. Dykes and Dr. Ricks Pluenneke this system uses a high-voltage bar that passes over weeds and discharges an electrical current through the vascular system of the plant, thus killing the plant. LASCO, Inc., has been formed to promote the services of this weed control system.*

* Gerald Dykes, President, LASCO, Inc., P. O. Box 187, Vicksburg, Miss., personal communication, 6 Jan 1976.
Principal Problems

76. There presently appears to be no major groundwater problems. Available air and surface water data indicate the following major problems:

a. Widespread pesticide contamination of lakes and streams in the Alluvial Plain.

b. Pesticide contamination of the air within the Alluvial Plain during spring and summer months.

77. The following problems appear to be present, but there are insufficient data to confirm or deny their existence:

a. Accelerated eutrophication of lakes, bayous, and wetlands within the Alluvial Plain.

b. Overabundance of suspended solids in water bodies throughout the basin, producing high turbidities in surface waters.

78. Sufficient knowledge of the surface waters in the Yazoo Basin is not available for adequate problem identification; thus, problems may exist that have not been detected.

Status of Available Data

Groundwater

79. Roy Newcombe, U. S. Geological Survey (USGS), Jackson, Mississippi, is of the opinion that groundwater data for the Yazoo Basin are good and are reasonably adequate.* This opinion is shared by the Lower Mississippi River study team1 and by the SCS.2

80. USGS is presently mapping the aquifers throughout Mississippi. These maps should update previously existing ones for the Yazoo Basin. A good discussion of the aquifers and their estimated yields is provided in a VXD Environmental Impact Statement and in the USDA's Yazoo - Mississippi River Basin Study, Mississippi.2 The same or similar information is available from other sources, but the primary data are derived

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* Roy Newcombe, USGS, Jackson, Miss., personal communication, 25 Sep 1975.
from the USGS. Other sources of groundwater data are records of the Mississippi State Health Department, Mississippi Board of Water Commissioners, and the Mississippi State Chemist.

**Surface water**

81. Water-quality records for surface water in the Yazoo River Basin are inadequate in one of two ways and often both: (1) inadequate coverage of chemical and physical parameters and (2) limited areal coverage.

82. USGS maintains computerized records (STORET) containing comprehensive chemical and physical parameters for the Yazoo River Basin, but areal coverage is poor on all parameters except stream stage and discharge. The Mississippi Game and Fish Commission records cover much of the basin, but the data are limited to a few chemical and physical variables. These records are also temporally and spatially disjunct. The universities within the basin plus Mississippi State University also possess surface water records of a few physical and chemical variables. These records are disjunct in both time and space. The Mississippi Air and Water Pollution Control Board currently monitors 5 physical and 33 chemical variables biweekly at 16 stations on rivers and streams in the Uplands of the basin. Data from all of these sources need to be integrated, synthesized, and stored in a central data system such as that recommended in the main text of this report.
PART VI: RECOMMENDATIONS

General

83. Recommendations presented in this appendix may be categorized as recommended actions and/or studies. Other recommendations for possible scopes of work include recommended sampling programs, sampling stations, and chemical and physical variables.

84. The Corps should investigate the factors contributing to the heavy streambed sedimentation occurring in channelized streams above the major flood-control reservoirs and in streams flowing from the Loess Bluffs into the Alluvial Plain. Concurrent with these investigations, the Corps should classify these sediments and determine the feasibility of their removal and use in a cost-defraying manner such as for construction purposes.

85. The ARS Sedimentation Laboratory, Oxford, Mississippi, has initiated erosion, sedimentation, and related studies in the Alluvial Plain at Friars Point, Mississippi, and is initiating similar studies near Glen Allen, Mississippi. Cooperation with the Sedimentation Laboratory on broad base studies would benefit the environmental conditions and economy of the Yazoo Basin.

86. The Alluvial Plain region contains approximately 66,000 surface acres of lakes and streams, and it is claimed that most of these acres are no longer productive of edible fishes. Agricultural practices, loss of water exchange, and fish access to lakes from major streams is believed to be responsible for the decline in production of fish.

87. Intensive studies and experiments on one or more of the lakes in the Yazoo Basin might elucidate the real causes for the fish population decline and enable many of the water bodies to be reclaimed. VXD has project work approved for the Wolf Lake-Broad Lake-Lake George Complex and the Bear Creek Watershed. Extra effort and project modification on one or both of these projects, combined with certain watershed management practices, could do much to establish the relative importance of stream access, lake flushing, and watershed management in the
Alluvial Plain. Modification of one of these projects to allow for maximum drawdown during autumn would allow for greater storage of spring floodwaters, and the ecological effects of the drawdown could be studied.

88. While the Yazoo-Mississippi Delta does not contain deep hollows that lend themselves to reservoirs, it does contain many swells and depressions that might lend themselves to temporary floodwater storage. In fact, these areas served just that purpose before levees prevented it. Many of these areas still are relatively undeveloped. All possible floodwater storage possibilities should be investigated.

89. SCS and private landowners have constructed many small reservoirs in the Yazoo Basin Uplands that aid in floodwater storage; however, many other probable sites for such reservoirs remain. Possibilities for small multiple-purpose reservoirs throughout the Yazoo Basin Uplands should be thoroughly explored and mapped.

90. Aquifer recharge areas should be located and managed to provide maximum recharge with clean waters. Operations (actions) that might cause deterioration of groundwater quality or quantity should be approached with extreme care or stopped.

91. Contaminants that contribute heavily to environmental pollution and the sources of these contaminants need to be identified and monitored. Innovative pollution-control measures are needed. In order to develop these control measures expeditiously, it will be necessary to identify modes of pollutant transport, then apply measures designed to interrupt the transport system at or near the source.

92. Certain insecticides are already known to be major contaminants in some areas. It is known that they are transported primarily by air and surface runoff, but the ratio of lake and stream entry via diffusion from the air to that via rainfall runoff needs identification and documentation.

93. The possible transfer of insecticides from suspended sediment to fish flesh needs to be investigated.

94. The Corps should cooperate with SCS, agricultural leaders in the Alluvial Plain, and other interested agencies and individuals to correct and improve land management practices in order to improve the
quality of surface waters. The Corps should be especially concerned with ensuring the use of proper management practices on Federal lands for which it is the responsible agency in order to serve as a model for other landowners.

95. The research, development, and evaluation of alternative land management techniques (e.g., minimum tillage procedures for cotton production and alternatives to present chemical insect controls) are needed. The Corps should cooperate with other Federal and local agencies in encouraging the development and implementation of those techniques that are environmentally sound and in discouraging those that are not.

**Proposed Study Program for the Yazoo Basin**

**Phases of study**

96. The first phase of the program (Phase I) for physicochemical characterization of the Yazoo Basin should include the following items:

a. Establish continuous contact lines with other agencies in the basin for the purpose of data and idea exchange. Provide mechanisms that will ensure continued interagency exchange of data and ideas relating to Yazoo Basin resource management.

b. Initiate a resource information system.

c. Inventory and assessment to provide data base and identify specific areas needing continued monitoring.

d. Identify and initiate needed experimental research that is applicable to the Yazoo Basin.

97. The following studies would be conducted under Phase II:

a. Continue information and idea exchange.

b. Redefine sampling stations and refine sampling equipment and techniques, installing necessary and available monitoring equipment to provide data needed on a continuing basis.

c. Continue experimental research where needed; refine, update, and add where needed.

**Sampling methodologies**

98. In order to provide representative weights to the study costs presented in the main text of this report, it was necessary to develop
preliminary study methodologies. These suggested methodologies reflect the types of sampling and testing that will have to be accomplished during Phase I in order to prepare the detailed scopes of work that will be developed later.

99. Additional or sufficient sampling will be accomplished to identify point source pollution and areas of pollution from nonpoint sources. The sampling scheme will be designed to identify pollution from short-term natural and unnatural activities in addition to long-term pollution.

100. Sediment samples. Samples will be taken as follows:
   a. On major flood control reservoirs: three replicates taken once near confluence of major streams entering reservoirs.
   b. On Yazoo River: three replicates taken once above and below confluence of tributaries and in tributaries.
   c. On tributaries of tributaries: three replicates taken once above and below confluence and in tributaries of tributary.

101. Field reconnaissance will be used to locate exact sampling stations and any stations deemed appropriate in addition to above-named stations. These samples will be analyzed for the variables listed in the following section, "Physical and Chemical Variables."

102. Water samples. Continuous discharge and gage measurements to be made:
   a. At each reservoir discharge structure.
   b. On the Yazoo River near Greenwood.
   c. At the locks structure on Steele Bayou.
   d. At discharge structures on the Big and Little Sunflower Rivers.
   e. On the Tallahatchie River below the confluence of Cassidy Bayou with the Tallahatchie River near Swan Lake.
   f. On all other sites presently being monitored in this manner by VXD.

103. Continuous trickle samples of water will be taken at each location and analysis performed for each of the chemicals listed under "Physical and Chemical Variables" until continued sampling shows the chemical to be unimportant as a contaminant. Biweekly grab samples of
water will be taken at these stations during high-water periods and intermittently during low-water periods. This sampling will also be continued until analyses show such chemicals to be unimportant as contaminants.

104. Intermittent discharge and water grab sampling will be accomplished during high-water and low-water periods at or near all stations identified for sediment sampling. Sufficient suspended and bed-load sediment sampling stations will be established on the Yazoo River tributaries to gain an accurate picture of sediment movement within the Yazoo Basin.

105. Turbidity will be measured at all water-sampling stations at times of water sampling.

106. Oxbow lakes. Drainage basins of all major oxbow lakes in the Yazoo Basin will be identified and land management (crops and cropping) practices documented. Sedimentation rates and patterns will be identified. Sediment sampling and water grab sampling will be accomplished on these samples in accordance with those listed under the following section, "Physical and Chemical Variables."

Air sampling

107. Ten stations will be selected to monitor the types and amounts of agricultural chemicals in the air in the Yazoo Basin. Primary emphases should be on insecticides, but other chemicals will be sampled where deemed advisable.

Physical and chemical variables

108. The task outlined is that of producing a list of physical and chemical variables for consideration in monitoring water and sediment quality in the Yazoo Basin. However, the lack of any specific objective other than to consider aspects of nonpoint-source water pollution management may lead to a number of possible combinations of variables.

109. It would be advantageous to assess inputs of total concentrations of chemical elements and compounds into various portions of the Yazoo Basin. Depending upon the location of the sampling station, some conclusions could be drawn relating these total concentrations (dissolved or particulate) to input sources, whether they be industrial, domestic,
or agricultural. With the water column and sediment data and a sampling scheme capable of defining short-term natural events (storm events and periods of peak biological activity) and unnatural events (dredging, agricultural activities, etc.), an evaluation of the influence and some statements of system effects might be made. A list of variables should include the following:

<table>
<thead>
<tr>
<th>Variables</th>
<th>Source (type)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major nutrients:</td>
<td></td>
</tr>
<tr>
<td>Phosphorus, total as P</td>
<td>Water and sediments</td>
</tr>
<tr>
<td>Nitrate + nitrite as N</td>
<td></td>
</tr>
<tr>
<td>Nitrogen, total Kjeldahl as N</td>
<td></td>
</tr>
<tr>
<td>Common constituents:</td>
<td></td>
</tr>
<tr>
<td>Bicarbonate, carbonate, calcium</td>
<td>Water (dissolved)</td>
</tr>
<tr>
<td>magnesium, sodium, potassium,</td>
<td></td>
</tr>
<tr>
<td>chloride, fluoride, silica,</td>
<td></td>
</tr>
<tr>
<td>sulfate</td>
<td></td>
</tr>
<tr>
<td>Trace elements:</td>
<td></td>
</tr>
<tr>
<td>Arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium and zinc, cyanide</td>
<td>Water (total and dissolved) Sediment (total)</td>
</tr>
<tr>
<td>Organics:</td>
<td></td>
</tr>
<tr>
<td>Organic carbon PCBs (total mass), Selected pesticides, herbicides, fungicides.</td>
<td>Water (total and dissolved) Sediment (Total)</td>
</tr>
<tr>
<td>Biological:*</td>
<td></td>
</tr>
<tr>
<td>Coliform, fecal</td>
<td>Water (total) and Sediment (total)</td>
</tr>
<tr>
<td>Streptococci, fecal</td>
<td></td>
</tr>
<tr>
<td>Physical-chemical:**</td>
<td></td>
</tr>
<tr>
<td>(1) Temperature, specific conductance, pH, dissolved solids, dissolved oxygen, turbidity, suspended sediment, alkalinity, total hardness, discharge</td>
<td>Water</td>
</tr>
<tr>
<td>(2) Eh, particle size</td>
<td>Sediment</td>
</tr>
</tbody>
</table>

* This biological category is here included because coliforms have by precedent come to be identified with water quality.

** This category includes direct measurements of an element or ion (e.g., dissolved oxygen and hydrogen as well as complex indices of combined chemical elements and compounds (e.g., alkalinity).

110. A tabulated presentation of the Yazoo Basin subdivided into areas distinguished by differences in these water-quality variables will provide three important products:

a. Identification of sources and sinks of various chemical substances within the basin.

b. Definition of areas for further study and guidance for scopes of work for those studies.

c. Information on water quality that is important to the short- and long-term land-use planning of the basin. (Each of the listed variables influences the suitability of the water for recreation, agriculture, or industry and controls the kinds of activity that can be developed.)
111. There is an obvious relationship between the physical and chemical variables and aquatic biological habitat, as habitat affects both the recreational and economic potential of basin planning. Another approach of the assessment of water quality that would be much more meaningful (interpretable) and less expensive is recommended, however, if biological habitat or recreational management is the primary objective.

112. Enough is understood or hypothesized within water-quality and biological literature to direct the measurement of only those variables that are most likely to produce a short-term biological effect. Long-term effects due to genetic mutation or chronic sublethal exposure are with few exceptions (those that can be elucidated) poorly understood. In this context it is suggested that the biologically available forms of elements and compounds listed previously and/or those variables that seem to have direct toxic or biostimulatory effects be considered:

<table>
<thead>
<tr>
<th>Variables</th>
<th>Source (type)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major nutrients: phosphorus, inorganic as phosphate (P04) Nitrates + nitrites as N Ammonia as N Ammonia as NH3</td>
<td>Water (dissolved)</td>
</tr>
<tr>
<td>Common constituents: Carbonate, calcium, magnesium, sodium, potassium, chloride, silica</td>
<td>Water (dissolved)</td>
</tr>
<tr>
<td>Physical-chemical variables: (1) delete hardness from previous list (2) Turbidity (3) Eh, particle size</td>
<td>Water and sediments</td>
</tr>
<tr>
<td>Organic: Same as in previous list</td>
<td>Water (dissolved)</td>
</tr>
<tr>
<td>Trace elements:* As in previous list, but, because of special analytical difficulties, consider arsenic and selenium only if known to be a problem</td>
<td>Water (dissolved) and sediments** (total)</td>
</tr>
</tbody>
</table>

* It is strongly suggested that the trace metals be assessed using a scanning technique such as emission spectrographic analysis or the recently developed plasma (ICAP) instrumentation. Any large-scale analytical program using techniques other than these is likely to develop cost and analytical quality problems.

** If a benthic invertebrate or demersal fish population is a resource under consideration, the sediments will provide a significant sink for metals that may be biologically available. A low-level total approach effort is initially suggested. Pending the results of the initial work, a more elaborate scheme to describe the nature of the sediment-metal bonds and interstitial water concentrations would be desirable.
113. It would be desirable, although this overlaps with the aquatic biota aspects of this study (Appendix D), to take advantage of the bioconcentration characteristics of selected invertebrates (e.g., certain pelecypods, ephemerids) and to use biomass of periphytic algal forms as indicators of eutrophication trends.

114. It is finally recommended that coordination with National Stream Quality Accounting Network being directed by USGS be established and maintained.
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Table Cl
Concentrations of DDT and Toxaphene in the Water and Sediments of Wolf Lake, 1967-1968 (from Reference 8)

<table>
<thead>
<tr>
<th>Date</th>
<th>Water Average</th>
<th>Water $s^2$</th>
<th>Sediment Average</th>
<th>Sediment $s^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>05-25-67</td>
<td>0.530</td>
<td>0.5673</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>06-27-67</td>
<td>0.090</td>
<td>0.0000</td>
<td>0.200</td>
<td>0.0750</td>
</tr>
<tr>
<td>07-02-67</td>
<td>0.008</td>
<td>0.0001</td>
<td>0.997</td>
<td>0.5110</td>
</tr>
<tr>
<td>07-28-67</td>
<td>0.082</td>
<td>0.0001</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>08-07-67</td>
<td>0.082</td>
<td>0.0001</td>
<td>0.997</td>
<td>0.5110</td>
</tr>
<tr>
<td>08-24-67</td>
<td>0.082</td>
<td>0.0001</td>
<td>0.997</td>
<td>0.5110</td>
</tr>
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<td>09-07-67</td>
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<td>0.0001</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>10-11-67</td>
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<td>0.0001</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>11-18-67</td>
<td>0.082</td>
<td>0.0001</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>12-19-67</td>
<td>0.082</td>
<td>0.0001</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
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<td>0.164</td>
<td>0.0021</td>
<td>0.598</td>
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<td>0.982</td>
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</tr>
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<td>0.0960</td>
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<td>0.0233</td>
<td>1.437</td>
<td>0.6290</td>
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<td>0.6470</td>
</tr>
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<td>0.982</td>
<td>0.3950</td>
</tr>
<tr>
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<td>08-06-68</td>
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<td>--</td>
<td>--</td>
</tr>
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<td>--</td>
<td>--</td>
</tr>
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<td>--</td>
<td>--</td>
</tr>
<tr>
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<td>0.102</td>
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<td>1.594</td>
<td>0.0700</td>
</tr>
</tbody>
</table>

(Continued)

Notes: Average values for water are given in parts per billion; average values for sediment are given in parts per million.

$s^2$ = sample variance

In double entries under sediment, the first value is for determination made on wet sediment; the second value is for dry sediment.
<table>
<thead>
<tr>
<th></th>
<th>p, p'-DDT and Metabolites</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>Average</td>
<td>s^2</td>
<td>Average</td>
<td>s^2</td>
</tr>
<tr>
<td>02-07-68</td>
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<td>0.0647</td>
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<td></td>
<td>1.859</td>
<td>0.3910</td>
<td>0.2110</td>
<td>--</td>
</tr>
<tr>
<td>06-04-68</td>
<td>0.497</td>
<td>0.0040</td>
<td>0.0853</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>1.828</td>
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<tr>
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<td>--</td>
</tr>
<tr>
<td>09-25-68</td>
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<td>0.0457</td>
<td>0.0766</td>
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</tr>
<tr>
<td></td>
<td>2.100</td>
<td>2.2559</td>
<td>0.2658</td>
<td>--</td>
</tr>
</tbody>
</table>
### Table C2
Concentrations of Methyl- and Ethyl Parathion in the Water of Wolf Lake, 1967-1968 (from Reference 8)

<table>
<thead>
<tr>
<th>Date</th>
<th>Methyl Parathion</th>
<th>Ethyl Parathion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average ppb</td>
<td>s²</td>
</tr>
<tr>
<td>08-24-67</td>
<td>0.016</td>
<td>0.0001</td>
</tr>
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<td>09-07-67</td>
<td>0.016</td>
<td>0.0001</td>
</tr>
<tr>
<td>09-20-67</td>
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</tr>
<tr>
<td>10-11-67</td>
<td>113.764</td>
<td>47,488.5200</td>
</tr>
<tr>
<td>09-05-68</td>
<td>2.700</td>
<td>43.6844</td>
</tr>
<tr>
<td>09-17-68</td>
<td>0.265</td>
<td>0.0509</td>
</tr>
</tbody>
</table>
Table C3
Concentrations of DDT, Toxaphene, Methyl Parathion, and Ethyl Parathion in the Water of Mossy Lake, 1967-1968 (from Reference 8)

<table>
<thead>
<tr>
<th>Date</th>
<th>DDT and Metabolites Average ppb</th>
<th>Toxaphene Average ppb</th>
<th>Methyl Parathion Average ppb</th>
<th>Ethyl Parathion Average ppb</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>p, p'-</td>
<td>s²</td>
<td></td>
<td>s²</td>
</tr>
<tr>
<td>05-25-67</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>06-27-67</td>
<td>0.030</td>
<td>0.0000</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>07-28-67</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>08-24-67</td>
<td>0.020</td>
<td>0.0000</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>09-07-67</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
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<tr>
<td>09-20-67</td>
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<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>09-21-67</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>10-11-67</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>12-19-67</td>
<td>0.298</td>
<td>0.0296</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>02-22-68</td>
<td>--</td>
<td>--</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>03-07-68</td>
<td>--</td>
<td>--</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>03-19-68</td>
<td>0.120</td>
<td>0.0010</td>
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<td>*</td>
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<tr>
<td>04-15-68</td>
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<td>0.0038</td>
<td>--</td>
<td>--</td>
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<tr>
<td>05-01-68</td>
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<tr>
<td>05-21-68</td>
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<td>0.0050</td>
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<tr>
<td>06-04-68</td>
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<tr>
<td>06-18-68</td>
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<td>0.0005</td>
<td>--</td>
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</tr>
<tr>
<td>07-09-68</td>
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<td>--</td>
<td>--</td>
</tr>
<tr>
<td>07-23-68</td>
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<td>0.0001</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>08-06-68</td>
<td>0.005</td>
<td>0.0002</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

* Not sampled on this date.
(Continued)
<table>
<thead>
<tr>
<th>Date</th>
<th>DDT and Metabolites Average</th>
<th>2</th>
<th>Toxaphene Average</th>
<th>2</th>
<th>Methyl Parathion Average</th>
<th>2</th>
<th>Ethyl Parathion Average</th>
<th>2</th>
</tr>
</thead>
</table>
| 08-19-68   | --                          | -- | *                 | * | *                        | * | *                      | *
| 09-05-68   | 0.007                       | 0.0001 | --              | -- | 5.262                   | 128.0253 | *          | *
| 09-17-68   | 0.125                       | 0.0200 | --              | -- | 0.133                   | 0.0556  | *          | *
| 10-16-68   | 0.023                       | 0.0006 | *               | * | *                        | * | *                      | *
| 12-11-68   | 0.262                       | 0.2165 | 0.380           | 0.0040 | *                       | * | *                      | * |
Table C4
Concentrations of DDT and Toxaphene in the Sediments of Mossy Lake, 1968
(from Reference 8)

<table>
<thead>
<tr>
<th>Date</th>
<th>DDT and Metabolites</th>
<th></th>
<th>Toxaphene</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average ppm</td>
<td>$s^2$</td>
<td>Average ppm</td>
</tr>
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<tr>
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<td>0.421</td>
<td>0.1711</td>
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<tr>
<td>06-04-68</td>
<td>0.105</td>
<td>0.0024</td>
<td>0.0478</td>
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<tr>
<td></td>
<td>0.580</td>
<td>0.0205</td>
<td>0.2629</td>
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<tr>
<td>09-03-68</td>
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<td>0.0019</td>
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<tr>
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<td>0.2992</td>
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<tr>
<td>09-25-68</td>
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<tr>
<td></td>
<td>0.552</td>
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Note: In double entries, the first value is for determination made on wet sediment; the second value is for dry sediment.
Listed insecticides comprise 90 percent of all insecticides used in Mississippi. (Data obtained from Cooperative Extension Service, U.S. Department of Agriculture, Mississippi State University)

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<td>Azodrin</td>
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<td>77</td>
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<td>Dimethoate</td>
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<td>33</td>
<td>65</td>
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<td>Endrin</td>
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<td>25</td>
<td>112</td>
<td>98</td>
<td>275</td>
<td>242</td>
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<td>EPN</td>
<td>72</td>
<td>293</td>
<td>468</td>
<td>325</td>
<td>185</td>
<td>391</td>
</tr>
<tr>
<td>Methyl Parathion</td>
<td>5,500</td>
<td>5,400</td>
<td>8,300</td>
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<td>Toxaphene</td>
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<td>8,300</td>
<td>11,900</td>
<td>17,500</td>
<td>7,900</td>
<td>9,300</td>
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DISTRICT

Jackson

Figure C15. Streamflow stations and gages, VXD, 1974

LEGEND

INTERMITTENT DISCHARGE MEASUREMENTS
HIGHWATER DISCHARGE MEASUREMENTS
SELF-REGISTERING HIGHWATER GAGE

NOTES

CLASSIFICATION FOR DISCHARGE:
REGULAR SUFFICIENT MEASUREMENTS OBTAINED TO DERIVE DAILY DISCHARGE
INTERMITTENT SUFFICIENT MEASUREMENTS OBTAINED TO DETERMINE RATING CURVE
HIGHWATER SUFFICIENT MEASUREMENTS OBTAINED TO APPROXIMATE RATING CURVE
FOR FLOOD FLOWS

THIS SHEET SHOWS THE STREAM GAGING PROGRAM VXD FOR STREAMS SHOWN HEREON
AS OF 1974.

SPECIAL GAGING STATIONS AT WHICH NO REGULAR MEASUREMENTS WERE MADE
ARE NOT SHOWN.
APPENDIX D: AQUATIC RESOURCES OF THE YAZOO BASIN
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- Benthic Organisms D9
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**TABLES D1-D11**
U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

<table>
<thead>
<tr>
<th>Multiply</th>
<th>By</th>
<th>To Obtain</th>
</tr>
</thead>
<tbody>
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<td>inches</td>
<td>2.54</td>
<td>centimetres</td>
</tr>
<tr>
<td>feet</td>
<td>0.3048</td>
<td>metres</td>
</tr>
<tr>
<td>miles (U. S. statute)</td>
<td>1.609344</td>
<td>kilometres</td>
</tr>
<tr>
<td>square inches</td>
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<tr>
<td>acres</td>
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<td>ounces (mass)</td>
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<td>pounds (mass) per acre</td>
<td>0.4535924</td>
<td>kilograms per hectares</td>
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</table>
PART I: INTRODUCTION

1. The Yazoo Basin is characterized by a variety of aquatic habitats, both natural and man-induced. The predominant feature of the Upland area is the four large reservoirs constructed by the U. S. Army Corps of Engineers: Arkabutla, Sardis, Enid, and Grenada. Numerous smaller flood-control reservoirs have been constructed by the Soil Conservation Service (SCS) in the minor drainage basins of the Upland area.

2. The major tributaries to the Yazoo River in the Alluvial Plain area are the Coldwater, Little Tallahatchie, Yocona, Yalobusha, Tallahatchie, Big Sunflower, Little Sunflower, and Quiver Rivers; Bogue Phalia, Deer Creek; and Steele Bayou. Most of these have been directly influenced by channelization and by other flood-control efforts. Other prominent reaches of flowing waters include the Panola-Quitman Floodway and the Will M. Whittington Auxiliary Channel. Natural meandering of ancient rivers and geological processes have resulted in the establishment of many oxbow lakes, sloughs, marshes, and backwater areas.

3. This appendix summarizes pertinent published literature regarding the aquatic resources of the basin; the Bibliography contains additional references to literature that will be of assistance in research involved with such resources. Part II describes aquatic biota and macrophytes of the basin. The aquatic biota is divided into three subsections: plankton, benthic organisms, and fisheries. These categories of aquatic biota are discussed separately relative to past investigations that have been conducted within the reservoirs of the Upland portion of the basin, the Yazoo River and tributaries, and the standing waters within the Alluvial Plain area. Part III presents an evaluation of the data and identification of existing data gaps on the aquatic systems of the Yazoo Basin, and Part IV presents recommendations for investigations needed to fill these data gaps and to make adequate evaluations of the ecological status of the aquatic systems within the basin.
PART II: DESCRIPTIONS OF AQUATIC BIOTA AND MACROPHYTES

Plankton

Upland reservoirs

4. Plankton studies of the Yazoo Basin have been limited. The most comprehensive studies have been conducted at the four major Upland flood-control reservoirs: Arkabutla, Sardis, Enid, and Grenada. Preliminary studies on these reservoirs have been reported in unpublished masters theses.1-4

5. McGaha and Knight5 reported the species composition of plankton collected with a No. 25, silk, bolting-cloth net from Arkabutla, Sardis, Enid, and Grenada Lakes during the spring and summer of 1955, 1958, and 1964; they also reported some quantitative plankton data for these years.6 A total of 64 phytoplankton genera and 46 zooplankton genera were identified from stations above the dam and below the spillway of each reservoir. Tables 1-8 of McGaha and Knight5 present the plankton composition of each reservoir for 1955, 1958, and 1964.

6. McGaha and Knight5,6 indicated that plankton were generally found in low densities in all four reservoirs. The maximum phytoplankton concentration was 7462 per litre in 1964 at Enid Lake (Table D1). A zooplankton maximum of 6750 per litre was found in Grenada Lake during 1955. Although the data are limited, there was an apparent general increase in phytoplankton standing crop between 1955 and 1964.

7. Since these studies were limited to only a short period during each of the 3 years, many genera present in the reservoirs may not have been identified. Plankton generally exhibit seasonal and yearly fluctuations, and sampling should be conducted at all seasons of the year to obtain a more complete determination of the planktonic component of aquatic systems.7,8

8. McGaha and Knight5,6 indicated that the dominant and most frequently collected phytoplankter was Mougeotia. Keratella was the most representative rotifer and was found in almost all samples. Several genera of phytoplankton and zooplankton were reported that were
considered to be dominants; however, differences among reservoirs or years were not distinguished in the following tabulation, which shows dominant genera of plankton found in Arkabutla, Enid, Sardis, and Grenada Lakes in 1955, 1958, and 1964.\

<table>
<thead>
<tr>
<th>Phytoplankton</th>
<th>Zooplankton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceratium</td>
<td>Bosmina</td>
</tr>
<tr>
<td>Eudorina</td>
<td>Cyclops</td>
</tr>
<tr>
<td>Gloeocystis</td>
<td>Daphnia</td>
</tr>
<tr>
<td>Mougeotia</td>
<td>Diaphanosoma</td>
</tr>
<tr>
<td>Nodularia</td>
<td>Diaptomus</td>
</tr>
<tr>
<td>Polycystis</td>
<td>Diffuglia</td>
</tr>
<tr>
<td>Staurastrum</td>
<td>Filinia</td>
</tr>
<tr>
<td></td>
<td>Hexarthra</td>
</tr>
<tr>
<td></td>
<td>Holopodium</td>
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<tr>
<td></td>
<td>Kellicottia</td>
</tr>
<tr>
<td></td>
<td>Keratella</td>
</tr>
<tr>
<td></td>
<td>Polyarthra</td>
</tr>
<tr>
<td></td>
<td>Trichocerca</td>
</tr>
</tbody>
</table>

9. Plankton samples taken in the tailwaters below the four reservoirs indicated that populations, although low in total numbers, varied with season and flow conditions. McGaha and Knight attributed plankton sparsity in these reservoirs to high turbidity, low pH, low carbonates and bicarbonates, and low silicates.

10. Knight and McGaha, in a more recent investigation, collected 85 species of rotifers from the four major flood-control reservoirs and their tributaries. Rotifers, primarily Polyarthra dissimulans and Keratella cochlearis, composed the largest percentages of the total zooplankton populations in bay areas where stream and reservoir waters mixed. They were less abundant in streams and in reservoir areas not in direct contact with inflowing stream waters.

**Yazoo River and tributaries**

11. The Gulf South Research Institute (GSRI) conducted plankton studies at three locations in the Yazoo River above and below the location of a proposed upper auxiliary channel being considered as a means to provide more efficient drainage of land in the northwestern part of the state. Because of inadequate sample size for phytoplankton and unknown sample size for zooplankton, the data were strictly qualitative and are, therefore, of little value in developing a data base for the
project area. The quantitative values reported for zooplankton should also not be considered valid because of the extremely large net size used (No. 6 = 239 μm). Weber recommends a No. 20 net, which has a mesh size of 76 μm, for general zooplankton collections in fresh water. Smaller zooplankters such as protozoa and larval forms may pass through nets even with 76-μm mesh size.

12. The only true zooplankters that GSRI collected were representatives of the Copepoda. Other organisms collected along with the Copepoda in the samples were macroinvertebrates such as oligochaetes, crustaceans, and insects. These results probably reflect the mesh size of the sample net rather than the true zooplankton composition.

13. A total of only three genera of phytoplankton were collected by GSRI from these same three stations. These were the diatom Melosira; the blue-green algae Oscillatoria; and a flagellate, Euglena. All three stations showed very sparse populations, and no station was characterized by more than two genera of phytoplankton.

Standing waters in the Alluvial Plain Area

14. Plankton populations have been investigated in several oxbow lakes in the Yazoo Alluvial Plain area. A Mississippi Game and Fish Commission (MGFC) study reported standing crops of phytoplankton and zooplankton from Wolf and Mossy Lakes that were found in collections made monthly from May 1967 to October 1968. GSRI sampled Six Mile Lake for true free-floating plankton and epiphyton (attached algae) populations and determined primary productivity. GSRI also sampled for attached algae in Ascalmore Creek, Tippo Bayou, and the McIntyre Scatters area. A study made by the Water Resources Institute, Mississippi State University, described the aquatic habitat found in two wildlife refuges in the state.

15. MGFC studies. Bingham reported a total of 75 plankton taxa that were collected from Wolf and Mossy Lakes. Forty-seven of these were phytoplankton and most were green algae. Zooplankton was represented by a total of 28 taxa with the rotifers comprising the largest portion of the total number of taxa. During the time that the study was being conducted, Wolf Lake was considerably more contaminated with
pesticides than was Mossy Lake. Wolf Lake was bordered by land being intensively farmed for cotton. Mossy Lake was located in an area farmed for soybeans, which require considerably less pest control.

16. Plankton populations decreased considerably during 1968 in Wolf Lake. This decrease accompanied an increase in insecticide and turbidity levels in the lake. The major decrease was in the phytoplankton populations (Table D2). Zooplankton also decreased in Wolf Lake during the second year of the study but not to the extent shown by the phytoplankton. Total production was apparently low in Wolf Lake during the entire study period.

17. Bingham indicated that Wolf Lake had been chosen for the study because of decreased fishing success in the lake, and suggested that insecticides were responsible for this decline during the past years. It is uncertain as to whether this decreased fishing resulted from direct contamination from pesticides, accumulation of pesticides through the food chain, or the decreased production of plankton resulting from increased turbidity and insecticide levels. It is likely that the decreased fisheries of Wolf Lake have resulted from the high levels of pesticides in the water and sediment, although the mechanisms by which the toxicants have affected the production of fish are unclear.

18. GSRI studies. The GSRI study of Six Mile Lake was limited to a single sampling date in November 1972. Little interpretive value can be obtained from data collected on a single sampling date. Analysis is further hampered in this case because the sampling was late in the fall when plankton populations are normally approaching the yearly quantitative minimal.

19. GSRI did state, however, that for this one sampling date the diatoms were the single most abundant group. Plankton identified were Coscinodiscus, Stephanodiscus, Scenedesmus, Fragilaria, Pediastrum, Euglena, Eudorina, Navicula, and Anabaena. The presence of other groups of algae, particularly the blue-greens (Anabaena), indicates that if samples were collected during additional seasons of the year, a different species composition would most likely be present. This additional seasonal information is necessary to determine if problem growths
of algae occur in Six Mile Lake. The species composition of attached algae reported by GSRI for Six Mile Lake was very similar to the composition of the phytoplankton. This gives some indication that the attached algae are probably as important, if not more so, in the total primary production of this lake as the phytoplankton.

20. GSRI reported an extremely high primary productivity measurement of 3.2 g of carbon per cubic metre per hour. No methods were stated, other than that production was measured by a carbon-14 technique; therefore, this single value should not be accepted as absolute. Duplicate measurements should have been made, and the hour of the day that the analysis was performed and amount of carbon-14 added to the sample should have been indicated.

21. The algae in McIntyre Scatters area was also sampled by GSRI. Although diatoms were determined to be the dominant group of microflora, no mention was made of the habitat type sampled (i.e. marsh, limnetic zone, littoral zone, etc.), nor whether the sampling was for free plankton or attached algae. The single most abundant taxa found, however, was the blue-green algae Oscillatoria. The only other algal taxa found were diatoms: Asterionella, Coscinodiscus, Cymbella, Navicula, Melosira, and Diatoma.

22. Wildlife refuges. Arner et al.\textsuperscript{13} described the aquatic habitat found in the Yazoo Refuge located in the Yazoo Basin and in the Noxubee Refuge located in the interior Flatwood Soils. Plankton were collected by filtering 400 ml of water from the upper 8 in.* of the littoral zone (area with rooted aquatic plants). From these samples, standing crop evaluations were estimated and chlorophyll, an estimate of photosynthetic potential for the system, was determined.

Benthic Organisms

23. Many species of benthic organisms are vital components of the

* A table of factors for converting U. S. customary units of measurement to metric (SI) units is found on page 3.
diet of freshwater fishes. Benthic populations are often studied to determine the water quality of streams and lakes. They are useful indicators of water quality for several reasons. A relatively long sessile life, the tolerance of some benthic species to specific pollutants, and the sensitivity of others to even low concentrations of pollutants enable a competent researcher to determine reliably if pollution is occurring in an aquatic system and to derive information as to the types of pollutants entering the system.\textsuperscript{14}

**Upland reservoirs**

**Major reservoirs.** Published research on benthic populations in flood-control reservoirs in northern Mississippi is scant. Millican and McGaha\textsuperscript{15} describe the benthic composition in Sardis Lake. Diptera dominated the benthic communities at the 29 stations sampled and chironomids were found in greatest biomass and numbers during the study. The phantom midge, *Chaoborus*, was second in abundance, followed by tubificids, sphaerids (fingernail clams), and the burrowing mayfly Hexagenia. Millican and McGaha reported that mud substrates supported the most diverse and largest populations of benthic organisms and that fluctuation of water level, predation, and sedimentation were factors that affected productivity in Sardis Lake.\textsuperscript{15} The MGFC found that clay substrates in Sardis Reservoir were least conducive to recolonization of benthic organisms following dewatering that occurs as a result of water-level manipulation.\textsuperscript{16} Millican and McGaha's observations were based upon benthic organisms collected with an Ekman dredge. An Ekman dredge, lightweight and spring operated, is recommended only for use in substrates that are loose, but cohesive. If substrates such as sand, hard clay, or gravel were present at the sampling stations, as were indicated by MGFC,\textsuperscript{16} a different type of dredge, such as a Petersen or Ponar, should have been used to determine effectively the role of substrate in determining the benthic standing crops.

25. During a study on effects of overland treatment of organic wastes, Franciques and Newbry sampled benthic organisms from five stations in Arkabutla Lake.\textsuperscript{17} Benthic species that are considered to be tolerant to oxygen-demanding wastes were found in greatest numbers
in this baseline study. Species diversity and evenness indices indicated that the aquatic habitat at the five stations was of low to intermediate quality. The authors suggested that turbidity was probably responsible for this poor water quality. McGaha and Steen\textsuperscript{18} also noted the effects of turbidity on benthic organisms in flood-control reservoirs in northern Mississippi.

26. Aside from these studies, most research on benthic organisms of Upland reservoirs has not been published, but results are found in theses and dissertations that are available in the libraries of the universities at which the work was conducted. Most works of this type are good but are necessarily limited in scope, duration of sampling effort, and locations of sampling stations. Some of these studies may be of value in providing a baseline for delineation of long-term impacts and are therefore listed in the Bibliography for future reference and use.

27. Small reservoirs. SCS\textsuperscript{19} has recently released a report on the Yazoo Basin that indicated its plans for the construction of approximately 760 small flood-control reservoirs within the Uplands of the Yazoo Basin. These small reservoirs, in addition to 300 that have already been constructed, could supply needed habitat for benthic organisms if properly designed and managed. The most detrimental condition at present is the rapid siltation that has continued in these impoundments. Most benthic organisms require a stable substrate for colonization; in addition, fine silts tend to smother important benthic organisms such as the various species of sprawling mayflies.

28. Small Upland tributaries and reservoirs provide local recreational opportunities and at the same time may provide drifting benthic organisms and plankton to aquatic habitats in lower elevations. This drift of organisms can in many situations provide an important base for food webs supporting fish.

29. Representative reservoirs from different types of drainage basins should be studied to determine their value to the aquatic resources of the basin. Many forested drainage basins have been recently clear-cut, and are being extensively farmed for row crops and for cattle production. Combinations of these land-use activities should be studied
to determine the effects of each type activity on the benthic fauna and the causes for these effects. The role of detritus, an important basis of certain food webs, should be determined for the different types of drainage basins in addition to standard physical and chemical measurements made in conjunction with these reservoir studies.

**Tributaries in the Alluvial Plain Area**

30. MGFC has completed two studies (1969-70 and 1971-72) on benthic organisms to determine possible polluted areas in the Yazoo Basin drainage system. These are essentially the only two studies completed to date that report data representing most of the Yazoo Basin below the four flood-control reservoirs. A less comprehensive study was conducted by GSRI in 1973.

31. **1969-1970 MGFC study.** Parker and Robinson reported the results of investigating 11 stations (stations 1-11 in Figure D1) on the Yazoo River and its tributaries during summer and fall of 1969 and spring of 1970. A total of 37 macroinvertebrate taxa and two vertebrate species were found during the course of the study. Detailed tables of taxa and population densities are given in Tables 2-12 of Reference 20. The pollution-tolerant tubificid worm *Limnodrilus* was the most frequently found organism during the study. The greatest number of taxa found at any one sampling period was 16 at station 3 on the Yocona River below Enid Lake. This station was also characterized by the highest species diversity (Table D3).

32. The lowest species diversity and evenness was found at station 9 on the Yazoo River just below the city of Greenwood. The poor development of the benthic community at this station was attributed to water degradation caused by industrial and domestic effluents from the Greenwood area. With the exception of station 3, all stations, particularly in the lower part of the basin, showed benthic communities of overall low qualities. Siltation (caused by erosion), pollution from pesticides, and generally poor habitat caused by shifting substrates are probably responsible for these low-quality benthic communities.

33. Studies should be initiated to determine the causes for these problems, and techniques should be employed to encourage growth of
Figure D1. Locations of benthic sampling stations
benthic populations. Limestone revetments could provide stabilized habitat for essential benthic species, such as sprawling mayflies and caddisflies, in some areas. The feasibility of using revetment and the number of linear feet or miles that could benefit from revetment should be determined.

34. 1971-1972 MGFC study. Parker and Robinson evaluated the benthic communities relative to sources of pollution at 20 stations (stations 12-31 in Figure D1) in the Big and Little Sunflower Rivers, Deer Creek, and Steele Bayou drainage system. The 67 different taxa found during the study conducted during the fall of 1971 and winter, spring, and summer of 1972 and quantitative data for each sampling station are given in Tables 1-21 of Reference 21.

35. Parker and Robinson reported that the most degraded benthic communities existed just below the city of Clarksdale at station 13 (Figure D1) on the Big Sunflower River. Species diversity values calculated from data in Reference 21 for stations 12, 13, and 14 indicate the severity of pollution at station 13. The average values for species diversity at these stations were as follows: station 12, 1.58; station 13, 0.38; and station 14, 2.24. These data, though not conclusive, indicate that the upper Big Sunflower River can recover from effects of domestic sewage in a relatively short distance downstream. The species diversity of the benthic community at station 14 is better than even those above Clarksdale at station 12. Assuming that the habitats sampled were similar at stations 12 and 14, there is evidence to indicate that a moderate organic enrichment is beneficial to benthic communities in the Big Sunflower. The effects of varying benthic habitat through organic enrichment needs to be further explored by means of field and laboratory experiments.

36. Benthic communities at most stations varied with season, and with few exceptions the number of taxa decreased between September 1971 and August 1972. For example, station 16 (Figure D1) on the Quiver River was characterized by 15 taxa in September 1971, but only 5 taxa were found the following August at the same station. Assuming that all samples were taken from the same location at each station, some
environmental change was most likely responsible for the decreased number of taxa found during late summer 1972.

37. Eight of the 10 taxa that disappeared from the station on the Quiver River were molluscs and two were mayflies. Because no size or biomass estimates were given for benthic organisms, relative ages of the molluscs cannot be determined. This is important in that it cannot be determined that stages in the life cycle of the various species were affected. Siltation, low pH, and high carbon dioxide content are known to be detrimental to molluscs.\(^\text{14}\) Certainly, pesticides can result in the elimination of many taxa of benthic organisms. Data supplied by Parker and Robinson indicated no appreciable amounts of pesticides in the water at station 16 (Figure D1); however, their tests did not measure quantities of toxaphene, the most frequently used pesticide in the State of Mississippi during 1972 (Table C5).

38. **GSRI study.** During a less comprehensive study of the Yazoo Basin, GSRI sampled benthic organisms at six stations (stations 32-37, Figure D1) once during the summer of 1973. The sample size was small (a total of 28 sq in., about 0.018 m\(^2\), from four core samples per station); therefore, the value of data generated is somewhat limited. The quantitative data were then multiplied by 55 to determine organisms per square metre. The major problem in this type of calculation is that the final results imply that at least one square metre was sampled at each station when only a fraction of a square metre was actually sampled.

39. Statistical analyses should have been performed to determine the number of cores that should have been taken at each station to account for the majority of variation in the community. GSRI also used an aquatic sweep net to qualitatively determine the species composition at stations 32, 35, and 37 (Figure D1). It should be noted that values given in Table 27 of Reference 10 should be considered as qualitative data and not as quantitative. Sweep netting was conducted only in open water and therefore gives some indication of abundance of species that were drifting.

40. **Comparison of MGFC and GSRI studies.** Some generalities can be drawn from MGFC's and GSRI's studies. The dominant benthic group found
during GSRI's study, as well as by the MGFC study during 1969 and 1970, was the aquatic oligochaetes. Station 34, which was located just below Greenwood on the Yazoo River, showed slight evidence of organic enrichment. Oligochaetes found at a density of 1100 per square metre (102 per square foot) were most abundant at this station. The MGFC study also found that station 9, 2 miles below Greenwood, was receiving organic wastes as evidenced by an oligochaete density of up to 157 per square foot.

41. The major difference between the two studies was that the MGFC investigators found more insect species and a greater concentration of insects than did GSRI. This apparent decrease in diversity with time could reflect the continuing demise of sensitive benthic fauna due to pesticides, turbidity, and siltation, but it is more likely the result of widespread habitat disruption caused by the flood of 1973.

42. Recommendations. While 31 stations have been sampled for benthic organisms in the Yazoo Basin tributaries, information is not available to determine with statistical validity the extent and cause for changes in the benthic communities. Continued monitoring on a seasonal basis is needed to determine the status of benthic populations in the Yazoo River and its tributaries. Well-designed studies would yield basic information to elucidate cause and effect relationships in the Yazoo Basin rivers and streams. These studies should determine (a) sources and effects of organic, inorganic, and toxic pollutants; (b) species present; (c) standing crop numbers and biomass; (d) species diversity; (e) predator-prey relationships; and (f) life histories of desirable benthic taxa. With studies of this type, prediction of primary and secondary impacts of any planned activity in the basin will be simplified and, more importantly, will be more accurate.

Standing waters in the Alluvial Plain area

43. MFGC studies. Benthic organisms have been studied in detail in only a few standing waters in the Alluvial Plain area. MGFC conducted detailed studies of two oxbow lakes, Wolf and Mossy Lakes, to determine the cause for decreased fishing success at Wolf Lake. At the time of the study, Wolf Lake was surrounded by land
that was intensively farmed for cotton while the land adjacent to Mossy Lake was farmed for soybeans. Since Wolf Lake had shown a decline in fishing success while Mossy Lake had not, the input of agricultural chemicals was implicated because soybean production does not require as much chemical application as does cotton.

44. Considerable benthic data were collected from the monthly sampling that was conducted from March 1967 to August 1968. These results were presented in tabular form in the appendix of Reference 12, and preliminary benthic data were presented in graphical form in an earlier report. The major difference in species composition observed was that small pelecypods dominated the benthic fauna of Mossy Lake and oligochaetes and the dipteran Chaoborus were dominant in Wolf Lake. Mossy Lake was also characterized by a greater density of midges, biting midges, snails, and leeches; and as a result, total density of benthic organisms were higher in Mossy Lake. Average benthic density was 54.6 organisms per square foot in Mossy Lake and 37.2 organisms per square foot in Wolf Lake. These differences were attributed to low dissolved oxygen conditions in the deeper waters of Wolf Lake and possibly reflects the result of greater pesticide and turbidity levels in Wolf Lake. Although Mossy Lake was more productive, the total density observed was low and much like the populations found in the tributaries of the Yazoo.

45. Mackenthun and Ingram, in a review of the literature, reported a range in density of benthic organisms of approximately 75 to 720 organisms per square foot in lakes and ponds of the northern United States. Organically polluted streams may show populations as high as 84,000 per square foot, but contamination from heavy loads of silt was shown to decrease benthic populations to less than 50 per square foot in a Georgia stream.

46. GSRI studies. GSRI also found a low benthic population in the summer of 1973 at White Lake. Six Mile Lake and McIntyre Scatters were sampled during 1972 and showed similar results. The benthic fauna at White Lake was limited to nematodes and snails at a total density of approximately 25 organisms per square foot. Substrate in Six Mile
Lake and McIntyre Scatters supported a total density of only 6 organisms per square foot. Nematodes, snails, and freshwater clams were found at Six Mile Lake, and nematodes and leeches at McIntyre Scatters. Sweep net samples around baldcypress trees and aquatic vegetation in Six Mile Lake, however, showed a clearer picture of the aquatic fauna available as fish food. Grass shrimp, crayfish, true bugs, beetles, dragonflies, damselflies, midges, snails, and clams were collected. These results indicated the importance of aquatic macrophytes and submerged trees as substrates for aquatic fauna. Similar results were obtained by sweep netting in McIntyre Scatters.

47. **Wildlife refuges.** Arner et al. determined the wet-weight biomass of aquatic fauna relative to the abundance of aquatic plant communities of the Yazoo and Noxubee Refuges. The dominant plant species in the Yazoo Refuge were *Hydrocotyle ranunculoides*, *Jussiaea diffusa*, *Spirodela polyrhiza*, *Myriophyllum brasiliense*, *Wolffiella floridana*, *Limnobium spongia*, and *Wolffia columbiana*.

48. The greatest aquatic invertebrate biomass occurred during fall and the lowest values were found during winter in both refuges. The greatest ratio of invertebrate-to-plant biomass also occurred during the fall in both refuges. This relationship in the Yazoo Refuge was related to the growth of *J. diffusa*, which only occurred during the fall months. *H. ranunculoides* was the only species of aquatic vegetation that was present during the entire year, and it also supported a high ratio of invertebrate-to-plant biomass.

49. Following the winter minimum, plant and invertebrate biomass increased. Spring production of invertebrate biomass was greater in the Yazoo Refuge and was attributed to the generally more productive waters of the refuge. Shallow-water areas, such as those in the Yazoo Refuge area, are important in that they often contain these growths of aquatic vegetation and trees that provide substrate for growth of aquatic invertebrates. These invertebrates in turn provide food for fish. Such systems are important to waterfowl and other wildlife. These feeding relationships need to be adequately quantified and described for the sloughs, marshes, swamps, and oxbow lakes of the river basin.
50. The problems associated with aquatic biota that have been most extensively emphasized relate to the decline of fisheries in the basin. While some research indicates a generally low production of all elements of the aquatic food chain, the general public is not familiar with this research. MGFC has conducted several studies of tributaries and lakes of the basin and has described the nature of the fisheries problems in the study area. 16, 25-29

51. Tributaries. Channelization of streams in the Upland area of the basin is apparently the primary factor that has led to decreased sport fisheries within this region. One prechannelization and post-channelization study by MGFC describes the drastic change that occurs in tributaries following this type of construction activity. 25, 26

52. MGFC studied the reach of the Tippah River that was channelized during 1965. Standing crop biomass of fish dropped from 240.7 lb per acre during 1964 to only 4.8 lb per acre in 1968, and had recovered to only 20.8 lb per acre in 1971. An almost complete disappearance of fish species other than minnows accompanied this decrease in total standing crop. The few channel catfish that remained had an average weight of less than 4 oz per fish during 1961 and less than one-half oz per fish during 1968. Species diversity dropped from a high of 2.8 prior to channelization to 1.23 six years after the construction activity.

53. While the changes brought about by channelization were obviously detrimental in this one case study, the magnitude of the problem is difficult to grasp. For example, some 55 miles of the Tippah River alone have been channelized. 26 The channelization of large lengths of tributaries results in compound effects on the aquatic environment. Many bends in the natural river are cut off from the normal flow of river water; as a result, many of these areas remain to stagnate and others that are deep enough to allow beneficial production no longer have entrances to the river and yield very little ecological benefit to the main tributaries. Poor access exists to most of these
artificially created oxbow lakes, and thus they provide little recrea-
tional benefit to man. Productive backwater areas are often destroyed
during channelization or are soon lost afterward due to siltation.

54. SCS has channelized approximately 519 miles of streams in the
Upland area of the Yazoo Basin. No new channel construction is
planned in this area.

55. Small reservoirs. SCS has constructed approximately 300 small
watershed impoundments and recommends construction of approximately 760
additional structures. If properly designed and managed, these watershed
reservoirs can provide much needed recreation in the Upland areas. The
literature indicated, however, that many of these small, shallow reser-
voirs are serving primarily as sediment traps. Channelization and
clear-cutting upstream of the impoundments and inadequate bank stabili-
zation techniques have been blamed for much of the erosion and sedimenta-
tion problems.

56. Major reservoirs. Arkabutla, Sardis, Enid, and Grenada Lakes,
the four major flood-control reservoirs, provide most of the sport
fishery in the northern portion of the Yazoo Basin. MGFC has gathered
much data for the purpose of managing fish production in these reser-
voirs (Table D4). Detailed analyses and data from these studies are
displayed by graphs and tables in their reports.

57. Total standing crop has fluctuated but has remained relatively
unchanged during the past 20 years (Table D5). Grenada Lake has main-
tained a higher standing crop than the others as evidenced by the re-
results of rotenoning cove areas by MGFC.

58. The decreases in standing crop at each reservoir during 1966-
1967 were attributed to the results of more efficient sampling tech-
niques. Prior to 1965, block nets had not been used extensively to
prevent migration of fish into the rotenoned area. During 1966 fish
were collected for 2 days following treatment of an area; therefore,
the use of block nets gave a better estimate of the true standing
crops by preventing migration into and out of the treated areas. The
measurements of total standing crop are comparable, on the average,
to those found in other lakes and ponds supporting mixed populations of
fish species. Carlander also found average standing crops for individual species in mixed populations in North American Lakes similar to those found by MGFC in the flood-control reservoirs.

59. Tables D6-D9 indicate that the relative composition of biomass per species, like standing crop, has remained fairly constant through the last 20 years. Gizzard shad (Dorosoma cepedianum) has usually predominated in the reservoirs except in Arkabutla where buffalo (Ictiobus spp.) has tended to dominate. This could be a reflection of low plankton populations present in this reservoir due to high turbidity, which provides for the selection of nonplankton feeders such as buffalo. Buffalo also increased in Grenada Lake between 1967 and 1972. Grenada Lake has become more turbid in recent years as a result of erosion from unstabilized banks along feeder tributaries above the reservoir. Although gizzard shad are tolerant of suspended sediments, they are mainly phytoplankton feeders. Decrease in phytoplanktonic production as a result of turbidity will affect the growth of the gizzard shad and the recently introduced threadfin shad. Another problem affecting the standing crops of planktonic organisms is directly related to water quality. Hydrogen ion concentration in these reservoirs is low; most researchers have reported pH values between 6.0 and 7.2. Combined calcium and magnesium hardness is also low. Soft-water lakes of this type are generally recognized as supporting limited biotic populations.

60. Creel estimates have indicated that crappie (Pomoxis), primarily the white crappie (P. annularis), have consistently dominated the sport fishery at Sardis, Enid, and Grenada Lakes. Micropterus, including largemouth (M. salmoides) and spotted bass (M. punctulatus), has been the second most frequently caught genus. Other species sought by sport fishermen include the channel catfish (Ictalurus punctatus) and bluegill (Lepomis macrochirus). White bass (Morone chrysops) were shown in the 1973 creel census for Enid and Grenada Lakes, but the estimate of total harvest was less than 50 lb in Enid and less than 500 lb in Grenada.

61. Enid, which is the smallest of the four reservoirs (approximately 13,000 acres at mean pool), has consistently received the lowest
total fishing effort and through 1968 received the lowest fishing effort per acre. Grenada Lake, second largest of the four reservoirs (approximately 26,000 acres to mean pool), received the greatest fishing effort per acre through 1968. However, in 1972 and 1973, Grenada received the least effort per acre by sport fishermen. The individual fisherman has had the best fishing success in Grenada Lake. Sport fishermen have consistently caught the most numbers and weight of fish from Grenada except during 1972 when fishermen were successful in catching fish only on 53 percent of their trips. Catch per hour was considerably higher in Grenada Lake during the period from 1958 to 1966 (average = 1.12 lb per hour), but in recent years this has decreased to the catch rate shown by the other reservoirs since 1958 (average = 0.69 lb per hour). Creel censuses should be continued to determine the sport fishery trends in these reservoirs.

62. MGFC has stocked Enid Lake with walleye (Stizostedion vitreum vitreum) and white bass, Sardis with striped bass (Morone saxatilis), and Grenada with white bass. These predator fishes were introduced to provide additional sport fishing while controlling populations of large-sized gizzard shad. Threadfin shad (Dorosoma petenense) has also been introduced and because of its smaller adult size should provide a food source for the largemouth and spotted basses and for the young introduced predator species. The only known success in these stocking attempts has been with white bass in Enid and Grenada Lakes. The reasons for the varying success in this stocking program and the impact of introducing these predator species has not been determined. Nevertheless, MGFC has recommended construction of nursery ponds at each of the four major reservoirs for the production of striped bass. A nursery pond for this purpose has already been constructed on Grenada Lake and was scheduled for operation during 1975.

Yazoo River and Alluvial Plain tributaries

63. Results of sampling by MGFC$^{20}$ and GSRI$^{10}$ in the Yazoo and its tributaries are shown in Tables D10 and D11. Locations of the fish-population sampling stations are shown in Figure D2. All stations where water-quality samples had been taken were subject to pesticide
Figure D2. Locations of fish-population sampling stations, Yazoo Alluvial tributaries
contamination and water-quality degradation. The limited fisheries information that is available allows some generalities relevant to flowing water in the Alluvial Plain.

64. MGFC studies. It is apparent that game fish species such as the largemouth bass are on the decline in the Yazoo Basin area. MGFC reported \(^{20,21}\) that no bass and only limited numbers of other game fish species such as channel catfish, bluegill, warmouth (\textit{Lepomis gulosus}), white crappie, longear (\textit{L. megalotis}), green sunfish (\textit{L. cyanellus}), and flier (\textit{Centrarchus macropterus}) were found at sampling stations on Deer Creek, Steele Bayou, Bogue Phalia, and Quiver, Little Sunflower, Big Sunflower, Tallahatchie, and Coldwater Rivers. MGFC used rotenone at all stations.

65. Stations 4 and 5 (Figure D2) were on the Tallahatchie and Coldwater Rivers, respectively, which had been straightened, desnagged, or channelized in the vicinity of the sampling stations. The predominant fish species at stations 4 and 5 were similar to those found in the flood-control reservoirs. Gizzard shad composed approximately 38 percent of the total biomass at these two one-acre sampling stations. Smallmouth buffalo (\textit{Ictiobus bubalus}) and channel catfish produced greater than 20 and 10 percent, respectively, of the total biomass. White crappie were not found at station 4 but exceeded 5 percent of the biomass at station 5. The fish population was also less diverse at station 4. Only 8 fish species were found at station 4 as compared with a total of 21 species found at station 5. Carp (\textit{Cyprinus carpio}) were noticeably absent from these upstream stations. These fish population studies were conducted during September 1970 in conjunction with benthic sampling. Benthic species diversity was lower at station 4 but was less than 1.0 at both stations (Table D3) during September. It was suggested that stream channelization was responsible for the impoverished biota at station 4.

66. MGFC has sampled the Big Sunflower, Little Sunflower, Deer Creek, and Steele Bayou drainage systems to determine effects of pollution on fisheries resources. \(^{21}\) A summary of the results is shown in Table D11. The Big Sunflower fisheries increased in diversity.
downstream. Station 13 (Figure D2), just below Clarksdale, was the least diverse, with only four species in the collection. The harvest was dominated by carp. Water quality at this station was severely degraded by domestic sewage from the city. The Sunflower showed an indication of recovery downstream. Total species and the numbers of species composing greater than 5 percent of the total biomass increased downstream. The Quiver River was apparently in fair condition. Both stations 15 and 16 were dominated by channel catfish. The Bogue Phalia station was characterized by 17 species with the longear sunfish composing almost 50 percent of the total biomass. Deer Creek, which receives domestic sewage, pesticide, and herbicides along its course, was apparently in poor condition. The fish populations along Deer Creek were dominated by gizzard shad, golden shiner (Notemigonus crysoleucas), and yellow bullhead (Ictalurus natalis). An average of only six species were found at the three stations on Deer Creek.

67. The greatest number of species, 22, was found at station 27 on Steele Bayou. This station was dominated by freshwater drum (Aplodinotus grunniens) and gizzard shad. Station 30 on the lower reach of Steele Bayou was dominated by threadfin shad and gizzard shad.

68. Table D11 indicates the paucity of game fish in these drainage systems. A number of factors are undoubtedly responsible for the decline in game fish populations, but the primary cause has been attributed to the indiscriminate and increasing use of pesticides and herbicides on farmlands within the Yazoo Basin. Other causes are turbidity, sewage, stream alteration, fertilizer runoff, and industrial pollution.

69. GSRI studies. GSRI collected fish by electroshocking and seining at station 32 (Figure D2), which is at approximately the same location as station 4 sampled by MGFC on the Tallahatchie River. The sampling, conducted in 1973, resulted in the collection of 15 species of fish. The only two fish species that were found in common by MGFC and GSRI were the gizzard shad and smallmouth buffalo. GSRI found 13 species not collected by MGFC. GSRI indicated the presence of several minnows not found by MGFC, which collected blue (Ictalurus furcatus) and channel catfish and green sunfish not found by GSRI. Gizzard shad were abundant.
in the GSRI samples, composing 23 and 42 percent, respectively of the electroshocking and seining collections; paddlefish (Polyodon spathula) and six carp were also found. There appears to be a change in the specific structure of the fish community between the 1970 survey by MGFC and the 1973 survey by GSRI. The possibility remains, however, that the differences were directly related to the different selective sampling techniques used by the two research groups and that no real change had occurred in the structure of the fisheries during the 3 years between surveys.

70. **Longitudinal changes in species composition.** MGFC has not recently published any results from sampling on the Yazoo River main stem. GSRI has sampled the Yazoo River below Greenwood, above Belzoni, below the Will M. Whittington Auxiliary Channel (WWC), and in the upper reach of the WWC; and has also sampled the Yalobusha River above the confluence with the Tallahatchie (Figure D2). The results of these samples (Table D10) indicate a downstream change in species composition. The principal tributaries and the upper Yazoo River were dominated by gizzard shad, emerald shiner (Notropis atherinoides), and smallmouth buffalo; the middle reach of the Yazoo was found to be dominated by carp and green sunfish. Impoverished fish populations were found in Ascalmore Creek and Tippo Bayou. No recently published data are known to exist for the lower Yazoo River.

71. **Recommended studies.** The sampling conducted in the Yazoo River and tributaries has indicated that problems exist in the fisheries. Figure D2 indicates the areas that have recently been sampled. To determine the status of the fisheries adequately, additional sampling stations in the lower Yazoo, Big Sunflower, Yalobusha, Coldwater, Yacona, and Little Tallahatchie Rivers should be established and monitored for seasonal changes.

**Standing waters in the Alluvial Plain area**

72. **MGFC studies.** Several fisheries studies have been conducted on the standing waters of the basin. MGFC listed results of sampling approximately 30 lakes in the Alluvial Plain during the late 1950's and early 1960's. A large number of these lakes were shown to
support good populations of game fish including largemouth bass, spotted bass and various other members of the sunfish family. White crappie, black crappie (*Pomoxis nigromaculatus*), and catfishes were abundant in some of these lakes. Gizzard and threadfin shad were the most abundant forage fishes. Physicochemical data indicated a wide range in pH, alkalinity, and turbidity for these lakes. Thermal stratification evidently occurs between the depths of 3 and 6 ft in these lakes during the summer.

73. Following this study and as a result of the need to determine the effects of pesticides on fisheries in lakes of the basin, MGFC intensively sampled Wolf and Mossy Lakes and found that Wolf Lake contained no largemouth bass or crappies, and a mixed population of sunfish composed only 16.5 percent of the total fish biomass. Mossy Lake contained a standing crop of 530 lb per acre, which was three times as much as was found in Wolf Lake. Crappies and sunfish, including largemouth bass, spotted bass, bluegill, redear (*Lepomis microlophus*), and warmouth, composed 39.1 percent of the total biomass.

74. Insecticide levels were found to be higher in water, sediment, and fish flesh of Wolf Lake. Bluegill of Wolf Lake were also found to be more tolerant of endrin, toxaphene, and DDT. It was concluded that pesticides had resulted in the poor fisheries present in Wolf Lake.

75. GSRI studies. GSRI has recently conducted fish population studies on White Lake, Six Mile Lake, and McIntyre Scatters. White Lake was dominated by rough fish, including smallmouth buffalo and gizzard shad. Less than 3 percent of the total standing crop of this lake was game fish. Six Mile Lake was also dominated by buffalo but was also characterized by sport fishes, such as white crappie, largemouth bass, sunfishes, and blue catfish, which totaled over 25 percent of the total standing crop. McIntyre Scatters was dominated by bigmouth buffalo (*Ictiobus cyprinellus*), but combined game fish composed 29.8 percent of the total standing crop. Largemouth bass composed 22.1 percent of the total biomass.

76. Lake closures. Pesticide contamination has resulted in the closing of three Delta lakes, Mossy, Wolf, and Washington. It has
been recommended that McIntyre and Four-Mile Lakes be closed, and more closures to commercial fishing are anticipated in the future. Concentration of pesticides in amounts up to 1500 times the normal tolerated by susceptible fishes within the tissues of smaller fish such as mosquitofish (*Gambusia affinis*) and shiners present one avenue of introduction of lethal amounts to game fish populations. Other predator or scavenger organisms, both aquatic and terrestrial, are also susceptible to toxic quantities of pesticides via the food chain.

**Fish kills**

77. Numerous fish kills have been noted in the Yazoo Basin, but published data on these kills are not readily available. Most kills have been attributed to pesticide poisoning; however, there is no recent documentation to substantiate this claim. Members of the U. S. Army Engineer Waterways Experiment Station (WES) study team observed a fish kill during October 1975 on the Little Sunflower River. The kill occurred 2 days following a heavy rainfall. Pesticide poisoning was believed responsible because of the erratic movement of the dying fish.

**Rare and threatened fish**

78. The State of Mississippi has recently published a list of rare and threatened vertebrates of the State. Three fish species were listed that are known or are likely to occur in the Yazoo drainage basin. These include an undescribed darter (*Etheostoma* spp.) from the upper Yazoo system and two species likely to occur in major rivers: the paddlefish and the blue sucker (*Cycleptus elongatus*). The blue sucker has not been recorded in the Yazoo Basin; however, it may be found in anticipated studies. Other endemic species as yet undescribed may be present in springs along the Uplands; others may have already been eliminated due to man's intrusion into the basin.

**Aquatic Macrophytes**

79. GSRI and Arner et al. indicated the importance of aquatic plants to the freshwater ecosystems in the Yazoo Basin. Aquatic macrophytes and the trunks and adventitious roots of partially submerged...
trees, especially baldcypress and willow, provide habitat for macroinvertebrates, which in turn provide a food source for forage and game fish. Arner et al. provided good descriptions of the macrophytes in the Yazoo Refuge. Quimby and Kay have discussed the growth and biocontrol of alligator weed (*Alternanthera phyloxeroides*) with a host-specific moth relative to water quality in two oxbow lakes in the basin. Other references to aquatic growth in the basin have not been as complete. Recommendations have been made in some instances to control macrophyte growth along shorelines.

80. Studies should be undertaken to document the importance of macrophyte growth to the production of aquatic macroinvertebrates, following methodologies similar to those used by Arner et al. The plant communities throughout the basin should be described in as much detail as possible. Approximate percent of cover, depth of growth, and dominant plant species should be determined.
PART III: PROBLEMS AND DATA GAPS

Problems

81. It appears that the major problems affecting the game fishery in the Yazoo River Basin are the results of stream alteration, including channelization and siltation, and pollution from domestic sewage and industrial and agricultural sources. Stream alteration in the Yazoo Basin has resulted in increased flow rates, a lack of substrate and bank stability, less surface area for aquatic biota, increased turbidity during rainfall runoff, siltation, and a reduction in numbers and diversity of aquatic populations.

82. It is apparent that one action can compound the effect of another. As an example, the results of stream alteration projects may have detrimental impacts upon fish populations; the operations also increase drainage from agricultural lands, and those areas downstream are subjected to increased loads of agricultural chemicals and sediment. Increased runoff from higher elevations in the Alluvial Plain and Upland areas funnels downstream, causing widespread inundation of agricultural lands and wildlife habitat. While many fishermen take advantage of fishing from roadsides and along levees during flooding, most of the oxbow lakes, many of which are leased to hunting camps, become accessible only by boat.

83. Flooding has been natural in the basin, and in past years was beneficial to fisheries of the area due to the increased acreages available for spawning and for increased food supply. Flooding over vast amounts of agricultural lands may now be detrimental because of the increased pesticides and sediment that are carried into backwaters, marshes, and oxbow lakes in the Alluvial Plain.

84. Current projections by SCS indicate an adequate quantity of basin-wide surface waters for fisheries through the year 2000. Information from SCS, however, indicates that a deficit of approximately 6500 surface acres will exist basin-wide by 2030: approximately 1060 acres were projected to be needed in the Alluvial Plain and 5440 acres will be
lacking in the Upland to meet the increased fishing demand of the year 2030.

85. These projections were made with the presumption that the supply of waters available would not change in either the Alluvial Plain or the Upland. Although rates of sedimentation are not definitely known in the basin, all planned construction in the Alluvial Plain will lead to decreases in water areas; and since only small shallow-water impoundments are planned for the Upland areas, it seems likely that the deficit will be even greater than indicated, especially in the Alluvial Plain. The problem is further complicated by the fact that the increased demand was calculated by assuming a constant demand rate per individual fisherman. As technology advances and more leisure time is available, it is likely that the demand for recreation, including fishing, will increase at a greater rate than will the human population of the area.

86. Another concern that needs to be considered in these projections is the quality of water that will be present in the basin. While existing Federal regulations prohibit discharge of pollutants from any sources by 1985,\(^43\) the major pollution problem in the basin results from diffuse sources, primarily agriculturally related; therefore, this criterion probably cannot be attained within this time frame in the Yazoo Basin. Use of environmentally persistent pesticides will continue to degrade waters, particularly in the Alluvial Plain area of the basin, and eventually interstate waters will be detrimentally affected.

Data Gaps

87. To date there exists no documentation of the quantity of various types of aquatic habitat available in the Yazoo River Basin. Adequate descriptions of critical marsh and backwater areas are particularly lacking.

88. The literature indicates that streams, rivers, and lakes in the Yazoo Basin are characterized by low biological productivity, especially in the primary elements of the aquatic food chain.
(phytoplankton, periphyton, and macrophytes). Increasing levels of turbidity, sedimentation, and pesticides have been implicated as the main causes in the decline of sport and commercial fisheries in the basin. Limiting micronutrients may retard the growth of plankton, which are needed for growth of small forage fishes, and ultimately the large predator sport fishes including those presently being introduced into the flood-control reservoirs. Little research has been done, however, to determine the status of essential micronutrients in aquatic systems of the Yazoo Basin, and no controlled studies have been conducted to determine the true cause for the decimation of sport fish in the basin.

89. There apparently is no organized manner by which fish kills that might occur in the basin can be reported. MGFC currently lacks the manpower to investigate thoroughly the fish kills that are reported. Studies conducted on location are essential in order to determine the most probable causes of kills.

90. A major gap is the almost complete absence of readily accessible published records on commercial fishing in the basin. Commercial fisheries data should be obtained and quickly analyzed in order for responsible agencies to keep abreast of any changes in commercial fisheries of the basin. Rapid changes are generally brought to the attention of responsible agencies through complaints of dissatisfied fishermen. Gradual decreases in harvests could be documented by monitoring adequate records, and corrective measures could be implemented before commercial fisheries are depleted.
PART IV: RECOMMENDATIONS

91. This section contains recommendations to assist in the positive identification of problems relating to the aquatic resources of the basin and in the determination of steps that should be initiated to remedy current and projected future complications. While it is realized that many of these recommendations may fall outside of the Corps of Engineers' jurisdiction, they elucidate the necessity of a multidisciplinary, interagency approach to effect the soundest program to protect and enhance aquatic resources of the Yazoo Basin.

Aquatic Resource Quantification

92. The highest priority, based on the current and projected decreases in quality and quantity of aquatic habitat in the basin, is to develop a classification system of streams, rivers, lakes, swamps, backwater, and other surface-water resources of the basin. Quantification of these habitat types could be accomplished simultaneously with aerial photo interpretation of terrestrial resources. The derived data could be stored in the same resource information system recommended in Volume I.

93. The State of Mississippi should be receptive to the benefits that such information would produce, and future State management of the area would be eased. The State could follow the example of Oregon, Montana, and Colorado in requesting Federal funds to support their participation in the study. State and Federal response should be on a timely basis since this first phase is critical in the sense that data collected in this phase should precede activation of any succeeding phase. These data will also stand alone and provide a significant contribution to future management of the area.

94. Subsequent to developing the classification scheme, a few typical aquatic systems, including environmentally significant wetlands and unique ecological areas, can be selected for detailed study. The research endeavors should include primary productivity studies, standing
and wildlife. Access to larger and deeper cut-offs could be provided by roads and boat launching ramps. The U. S. Fish and Wildlife Service (FWS) has recommended the placement of weirs in many cut-offs in the Alluvial Plain.44

98. The impacts of channelization on aquatic biota and terrestrial habitat should be thoroughly assessed. Complete hydrologic studies should be conducted to determine the feasibility of alternatives to channelization for flood control.

99. FWS has a great interest in studies dealing with stream alteration. Their national study team located in Columbia, Missouri, is a contract management group with specific interests in stream alteration. The potential impacts of channelization, both positive and negative, upon the fish and wildlife of the area are great. A collaborative arrangement with FWS is a definite possibility and would be of benefit to all concerned parties. Impact studies as proposed here, which may extend into the next decade, will provide scientific data of immense value in land- and water-use management and could be continued in post-operational phase for relatively low cost.

Sedimentation

100. Since sedimentation is a recognized problem, a series of greentree reservoirs could also function as settling ponds or water-treatment areas. The State of Oregon has established a greenbelt area as a park along the Willamette River. Such an approach through land purchase and farming regulation could be realized for sections of the Yazoo and its tributaries. Adequate public access should be provided. Preservation, revegetation, and innovative techniques for stream alteration such as one-side clearing could be practiced given a reasonable promise of permanence associated with any activity located near a reservoir or a 50- to 200-ft border of a stream.

Productivity

101. Waters of the Upland are characterized by low productivity.
General water-quality parameters such as pH, hardness, and turbidity resulting from suspended solids, are thought to be limiting to these systems. Laboratory experiments using algal cultures should be designed to determine the limiting factors in Upland waters. Macronutrients and micronutrients should be considered as well as adjustments to pH, alkalinity, and turbidity. After the determination of limiting factors and the establishment of corrective measures, pilot field studies should be initiated to determine the feasibility of increasing productivity of natural waters in the basin. It is believed that attempts by MGFC to introduce predator fish species into the major flood-control reservoirs will not be successful until ample forage fish are available as a food source; likewise, the introduction of threadfin shad as a food source for the walleye and striped bass will not be successful until plankton productivity is increased.

**Agricultural Pollutants**

102. Continued use of persistent pesticides within the basin will ultimately result in the destruction of fisheries, particularly in the Alluvial Plain area. Decreasing the rate of decline of fisheries will depend on slowing the movement of pesticides into aquatic areas via floodwaters and suspended sediments and following airborne methods of applications. Even if it is decided that the basin should be abandoned as a wildlife and fishery sanctuary and becomes developed solely for agricultural use, increased usage of pesticides will eventually result in environmental problems in interstate waters. For these reasons, the Corps should strongly encourage research for effective nonchemical alternatives for insect and weed control within the basin. Based on current trends of petroleum supply and demand, it seems likely that, within a few years, continued use of petroleum-derived agricultural chemicals and present tillage practices will become economically infeasible. The Yazoo Basin presents an excellent opportunity to pioneer the development of techniques that would be compatible with sustaining economically feasible agricultural practices that would be beneficial
to maintaining adequate aquatic resources.

**Extra-Basin Resources**

103. If environmental and resultant problems cannot be effectively solved, particularly in the Alluvial Plain area, then the possibility of developing and enhancing recreational areas in adjacent drainage basins within the State of Mississippi should be considered. The Mississippi River could be developed to provide fishing and recreation for residents of the Yazoo Alluvial Plain area and to mitigate anticipated losses of aquatic resources within the Yazoo Basin. Construction of beaches and boat ramps and the placement of portable sanitary facilities are suggested.

**Conclusion**

104. The technology and ability are present to initiate innovative approaches to maintain and/or to increase good habitat for recreational and commercial fisheries. With a thorough understanding of historical conditions, existing status, and either potential or actual impacts of project construction, positive action could be initiated to enhance both aquatic and terrestrial habitat.

105. In summary, it is recommended that:

a. A classification and quantification system of aquatic habitats be pursued.

b. The actual baseline studies be conducted in typical and unique ecologically significant areas.

c. Innovative techniques be activated for a thorough understanding of the ecosystem to enhance all multiple-use aspects of the Yazoo Basin area.

d. Development of adjacent basins for aquatic resources be considered to mitigate anticipated loss of resources in the Alluvial Plain area.

106. Each recommendation should be approached on the basis of Federal-State cooperation and cooperative funding. A literature search should precede each segment, and proposals should be solicited.
from other Federal and State agencies and should originate from various facets of the Corps of Engineers. Thorough use should be made of the management, technical, and field capabilities within WES relative to the actual work proposal, review, and contract management.
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Table D1

Maximum Plankton Populations Found in Arkabutla, Sardis, Enid, and Grenada Lakes, 1955 and 1964 (Compiled from McGaha and Knight⁶)

<table>
<thead>
<tr>
<th>Plankton</th>
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<th>Sardis</th>
<th>Enid</th>
<th>Grenada</th>
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<td></td>
<td></td>
<td></td>
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<td>Surface</td>
<td>600</td>
<td>999</td>
<td>572</td>
<td>3618</td>
</tr>
<tr>
<td>Mid-depth</td>
<td>416</td>
<td>--*</td>
<td>602</td>
<td>1070</td>
</tr>
<tr>
<td>Zooplankton</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface</td>
<td>&gt;600**</td>
<td>1213</td>
<td>1230</td>
<td>1074</td>
</tr>
<tr>
<td>Mid-depth</td>
<td>&gt;416**</td>
<td>684</td>
<td>903</td>
<td>--*</td>
</tr>
</tbody>
</table>

* No quantitative data given.
** Symbol > indicates that in-text descriptions reported that zooplankton populations were larger than phytoplankton populations.
### Table D2
Mean Total Zooplankton and Phytoplankton Concentrations Collected from Mossy and Wolf Lakes May 1967 to November 1968*
(Compiled from Binghaml2)

<table>
<thead>
<tr>
<th>Sampling Date</th>
<th>Zooplankton Concentration, No./l</th>
<th>Phytoplankton Concentration, No./l</th>
</tr>
</thead>
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<td></td>
<td>Mossy Lake</td>
<td>Wolf Lake</td>
</tr>
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<td>161</td>
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<tr>
<td>June 1967</td>
<td>248</td>
<td>122</td>
</tr>
<tr>
<td>July 1967</td>
<td>297</td>
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<td>August 1967</td>
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<td>100</td>
</tr>
<tr>
<td>September 1967</td>
<td>110</td>
<td>339</td>
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<tr>
<td>October 1967</td>
<td>95</td>
<td>309</td>
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<tr>
<td>November 1967</td>
<td>123</td>
<td>151</td>
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<tr>
<td>December 1967</td>
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<td>283</td>
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<td>January 1968</td>
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<td>February 1968</td>
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<td>March 1968</td>
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<td>June 1968</td>
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<td>July 1968</td>
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<td>August 1968</td>
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</tr>
<tr>
<td>November 1968</td>
<td>70</td>
<td>91</td>
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* Mean concentrations were calculated from the total given for each date for surface, mid-depth, and bottom samples.
Table D3
Species Diversity, Evenness, and Number of Taxa of Benthic Organism Communities, Yazoo Basin
(Computed from Parker and Robinson20)

<table>
<thead>
<tr>
<th>Station Number*</th>
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<th></th>
<th></th>
<th></th>
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<td>4-8-70</td>
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</tr>
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<tr>
<td>$d$</td>
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<td>1.74</td>
<td>1.03</td>
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<tr>
<td>$e$</td>
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<td>0.52</td>
<td>0.44</td>
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<tr>
<td>No. of taxa</td>
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<td>Station 2</td>
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<tr>
<td>No. of taxa</td>
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<td>8</td>
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</tr>
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<td>Station 3</td>
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<td>2.78</td>
<td>2.67</td>
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<td>Station 4</td>
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<td>Station 6</td>
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(Continued)

Note: Station number refers to numbers shown in Figure D1.

$d$ = species diversity

$e$ = species evenness
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<td>(Periodically)</td>
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<tr>
<td>White crappie</td>
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<td>1972-1974</td>
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* A = Arkabutla; S = Sardis; E = Enid; G = Grenada
** Reference number in References of this appendix
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<th>Source of Report**</th>
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<td>1964-1966</td>
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<td>Artificial structures used for habitat</td>
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Table D5

Average Fish Standing Crop Biomass in Corps of Engineer Flood-Control Reservoirs

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<td>Sardis</td>
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<td>Grenada</td>
<td>234.0</td>
<td>152.5</td>
<td>229.4</td>
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* No data available
Table D6
Composition of Species in Rotenone Samples from Arkabutla Lake
(Compiled from data from Mississippi Game and Fish Commission27,28)

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<td>0.7</td>
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<td>11.2</td>
<td>10.0</td>
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<tr>
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<td>T</td>
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</tr>
</tbody>
</table>

T = trace
* Includes blue gill, longear, redear, warmouth, green, and orangespotted
** Minnows, darters, madtoms, and pirate perch
*** Chain pickerel, bowfin, carpsucker, spotted sucker, bullheads, and redhorse
### Table D7

**Composition of Species in Rotenone Samples from Sardis Lake**

(Compiled from data from Mississippi Game and Fish Commission27,28)

<table>
<thead>
<tr>
<th>Species</th>
<th>Percentage by Weight</th>
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<tr>
<td>Largemouth and spotted basses</td>
<td>7.2</td>
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<tr>
<td>Crappie</td>
<td>4.5</td>
</tr>
<tr>
<td>Sunfish*</td>
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<tr>
<td>Buffalo</td>
<td>3.2</td>
</tr>
<tr>
<td>Carp</td>
<td>0.6</td>
</tr>
<tr>
<td>Drum</td>
<td>8.9</td>
</tr>
<tr>
<td>Channel catfish</td>
<td>19.1</td>
</tr>
<tr>
<td>Blue catfish</td>
<td>22.0</td>
</tr>
<tr>
<td>Flathead catfish</td>
<td>0.2</td>
</tr>
<tr>
<td>Gar</td>
<td>0.1</td>
</tr>
<tr>
<td>Gizzard shad</td>
<td>22.0</td>
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<tr>
<td>Minnow**</td>
<td>4.6</td>
</tr>
<tr>
<td>Others***</td>
<td>0.4</td>
</tr>
</tbody>
</table>

* Includes bluegill, longear, rethead, warmouth, green, and orangespotted

** Minnows, darters, madtoms, and pirate perch

*** Chain pickerel, bowfin, carpsucker, spotted sucker, bullheads, and redhorse
Table D8
Composition of Species in Rotenone Samples from Enid Lake
(Compiled from data from Mississippi Game and Fish Commission\textsuperscript{27,28})

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</thead>
<tbody>
<tr>
<td>Largemouth and spotted basses</td>
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<tr>
<td>Crappie</td>
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<td>1.1</td>
<td>0.8</td>
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<td>7.8</td>
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\(T = \text{trace}\)
* Includes bluegill, longear, redear, warmouth, green, and orangespotted
** Minnows, darters, madtoms, and pirate perch
*** Chain pickerel, bowfin, carpsucker, spotted sucker, bullheads, redhorse, and white bass
Table D9
Composition of Species in Rotenone Samples from Grenada Lake
(Compiled from data from Mississippi Game and Fish Commission27,28)

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<tr>
<td>Other***</td>
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<td>2.1</td>
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<td>1.7</td>
<td>3.6</td>
<td>0.3</td>
<td>1.9</td>
</tr>
</tbody>
</table>

T = trace
* Includes bluegill, longear, redear, warmouth, green, and orangespotted
** Minnows, darters, madtoms, and pirate perch
*** Chain pickerel, bowfin, carp sucker, spotted sucker, bullheads, redhorse, and white bass
Table D10  
Summary of Fisheries Data from the Yazoo River and Principal Upstream Tributaries  
(Compiled from Mississippi Game and Fish Commission and Gulf South Research Institute)

<table>
<thead>
<tr>
<th>Station No.*</th>
<th>River</th>
<th>Total Species</th>
<th>Species with Biomass Exceeding 5 Percent of Total***</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Tallahatchie</td>
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<td>GS(37.8), SB(35.1), CC(10.0) SH(6.3)</td>
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<tr>
<td>5</td>
<td>Coldwater</td>
<td>21</td>
<td>GS(38.3), SB(20.2), CC(17.5) FD(8.1) WC(5.1)</td>
</tr>
<tr>
<td>32</td>
<td>Tallahatchie</td>
<td>15</td>
<td>ES(46.8), GS(22.9), SM(10.4), BS(8.5)</td>
</tr>
<tr>
<td>33</td>
<td>Yalobusha</td>
<td>24</td>
<td>SB(26.7), GS(18.6) BS(16.2), SG(13.3) ES(9.1) WB(5.8)</td>
</tr>
<tr>
<td>34</td>
<td>Yazoo</td>
<td>19</td>
<td>GS(24.7), SB(17.0), LG(13.8), SH(8.9), SG(7.0)</td>
</tr>
<tr>
<td>35</td>
<td>Yazoo</td>
<td>21</td>
<td>GS(50.6), C(27.4)</td>
</tr>
<tr>
<td>36</td>
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<td>27</td>
<td>C(21.7), GrS(18.6), SG(16.5), BS(10.1), LS(5.6)</td>
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<tr>
<td>37</td>
<td>Yazoo</td>
<td>23</td>
<td>GrS(27.8), C(21.8), BS(14.5), LS(7.4)</td>
</tr>
</tbody>
</table>

* Station numbers given in Figure D2  
** As determined by rotenoning at stations 4 and 5; electroshocking and seining at station 32; electroshocking, seining, and gill nets at stations 33-37.  
*** Percent composition in parentheses refers to results from rotenoning at stations 4 and 5, and electroshocking at stations 32-37.

BS = Blacktail shiner  
C = Carp  
CC = Channel catfish  
ES = Emerald shiner  
FD = Freshwater drum  
GS = Gizzard shad  
GrS = Green sunfish  
LG = Longnose gar  
LS = Longear sunfish  
SB = Smallmouth buffalo  
SG = Shortnose gar  
SH = Skipjack herring  
SM = Silvery minnow  
WB = White bass  
WC = White Crappie
Table D11
Summary of Fisheries Data from Big Sunflower, Little Sunflower, Deer Creek, and Steele Bayou
(Compiled from Mississippi Game and Fish Commission)

<table>
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<th>Station No.*</th>
<th>Drainage System</th>
<th>Total Species**</th>
<th>Species with Biomass Exceeding 5 Percent of Total***</th>
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<tr>
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<td>C(51.7), RC(19.4), YB(15.0), GS(13.9)</td>
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<tr>
<td>14</td>
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<td>GS(62.8), CC(17.4), LS(9.7), FD(5.6)</td>
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<tr>
<td>15</td>
<td>Quiver</td>
<td>17</td>
<td>CC(24.5), RC(22.4), C(22.1), FD(15.0), YB(7.9)</td>
</tr>
<tr>
<td>16</td>
<td>Quiver</td>
<td>16</td>
<td>CC(27.1), FD(20.8), OS(15.5), GS(12.6), C(10.9), YB(6.3)</td>
</tr>
<tr>
<td>17</td>
<td>Big Sunflower</td>
<td>13</td>
<td>GS(40.8), FD(23.5), RC(14.2), CC(10.8)</td>
</tr>
<tr>
<td>19</td>
<td>Deer Creek</td>
<td>8</td>
<td>GS(45.9), GoS(38.9), M(5.9)</td>
</tr>
<tr>
<td>20</td>
<td>Bogue Phalia</td>
<td>17</td>
<td>LS(49.6), YB(15.6), OS(11.9) GoS(5.9)</td>
</tr>
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<td>22</td>
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<td>7</td>
<td>GS(38.4), GoS(28.3), OS(17.2), HS(12.1)</td>
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<tr>
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<td>18</td>
<td>GS(44.5), C(11.5), ES(9.3), YB(7.0), W(6.5), SG(5.8)</td>
</tr>
<tr>
<td>27</td>
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<td>22</td>
<td>FD(29.2), GS(28.9), C(16.8), CC(13.8)</td>
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<tr>
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<td>30</td>
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* Station numbers given in Figure D2
** Number of species collected by rotenoning.
*** Percent composition in parenthesis refers to results from rotenoning at all stations.
C = Carp    GoS = Golden shiner    M = Mosquito fish    TS = Threadfin shad
CC = Channel catfish    GS = Gizzard shad    OS = Orangespotted sunfish    W = Warmouth
ES = Emerald shiner    HS = Hybrid sunfish    RC = River carpsucker    YB = Yellow bullhead
FD = Freshwater drum    LS = Longear sunfish    SG = Shortnose gar
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E2
CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

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</table>

* To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula: \( C = \frac{5}{9}(F - 32) \). To obtain Kelvin (K) readings, use: \( K = \frac{5}{9}(F - 32) + 273.15 \).
1. This appendix was prepared to provide the U. S. Army Engineer District, Vicksburg, with a detailed description of terrestrial resources of the Yazoo Basin. The description required a thorough examination of existing data and consultation with various Federal, State, and local agencies directly involved in resource utilization and planning. As a result of the examination, certain gaps were apparent in existing data; the complete data base would be necessary for effective planning of water and related land resources of the Yazoo Basin. The data gaps and other identified problems provided the basis for recommendations that attempt to address the data gaps and ways to alleviate the problem areas. This appendix represents the first in a series of steps necessary for effective planning and is designed to provide the basis for development of a future, more detailed analysis of terrestrial resources in the Yazoo Basin.
PART II: DESCRIPTION OF TERRESTRIAL RESOURCES

2. The Yazoo Basin is situated in the northwest quarter of Mississippi and encompasses approximately 8,547,000 acres or about 13,355 square miles.* It is about 200 miles in length and has a maximum width of approximately 110 miles. The climate is subtropical and characterized by an annual average precipitation of 50-56 in., an average temperature between 60° and 65°F, and an average annual growing season of 215-250 days.

3. Included within the basin are several sizeable rivers and associated creeks, bayous, oxbow lakes, swamps, and sloughs, all contributing to an interesting vegetational diversity. About 268 square miles of the basin are covered with water.

Early Development and Environmental Setting

4. Early settlers in the Yazoo Basin observed a sharp contrast in two major geomorphic regions. A natural bluff extending in a generally north-south direction nearly equally divides the basin into the Upland Region to the east and the Alluvial Plain to the west (Figure El). Each geomorphic region contains its own distinct forest communities.

5. The Upland Region (encompassing the Pontotoc Ridge, Flatwoods, North Central Hills, and the Loess Bluffs physiographic areas) primarily supported upland hardwoods with post oak (Quercus stellata), southern red oak (Q. falcata), white oak (Q. alba), mockernut hickory (Carya tomentosa), sweetgum (Liquidambar styraciflua), and elms (Ulmus spp.) often observed.¹⁻³ Small concentrations of loblolly pine (Pinus taeda) and shortleaf pine (P. echinata) were scattered throughout this area. The Alluvial Plain originally contained a gigantic bottomland hardwood forest intermingled with streams, lakes, bayous, and cypress brakes. Common forest species included overcup oak (Q. lyrata), water oak

* A table of factors for converting U. S. customary units of measurement to metric (SI) units is found on page E3.
Figure E1. Major geomorphic regions
(Q. nigra), willow oak (Q. phellos), tupelo-gum (Nyssa aquatica), green ash (Fraxinus pennsylvanica), water hickory (C. aquatica), and bald-cypress (Taxodium distichum).  

6. Early development in the Upland Region was concentrated in the flatter areas where forests were cleared and cultivated in cotton and corn. As the population expanded, vegetation on the slopes was cleared, exposing the loosely compacted soil to the erosive forces of wind and water. Uncontrollable erosion followed, leaving much of the Upland Region denuded of vegetation. By 1899, some parts of the loess hills were already literally washed away. Hutchinson et al. stated that much of the surface or virgin soil of the hills had washed into the valley and that many crops in the Upland Region were grown on what was formerly subsoil.

7. Settlement in the Alluvial Plain was inhibited by poor drainage. Early settlers were initially confined to the better drained sites along natural levees where they began to carve out small openings in the forest. Cotton and corn were the principal agricultural crops. Although subject to flooding, the Alluvial Plain soils were extremely fertile. As a result, additional settlers were attracted to the highly productive farmland of the basin. Soon the more elevated, better drained sites were cleared, necessitating movement into less desirable, poorly drained areas. This slow conversion of forest to cropland was accelerated in the 1880's when the demand for cotton increased.

8. Coupled with the increased demand for cotton was an expanding population that required increasing quantities of lumber for home construction. Small sawmills flourished throughout the area and the lumbermen selectively harvested high-quality trees. Often a small sawmill would be moved into an area; the easily accessible forest cleared; and then the sawmill simply relocate elsewhere, leaving behind fields void of their original high-quality timber. According to Ferris, one of the early practices of farmers was to follow the sawmills so that about all the farmer had to do to start farming was remove the stumps from the cleared forests. These "cut out and get out" practices by the lumber industry caused a rapid decline in the quality and quantity of
timber over the entire Yazoo Basin, particularly in the Alluvial Plain.

9. Clearing practices by lumbermen and farmers initially had a beneficial effect on wildlife populations. Clearing increased the amount of sunlight reaching the forest floor, stimulating the growth of understory vegetation. This understory growth provided a new source of food and cover for many wildlife species. Records indicate that populations of some game species increased after the initial clearing of small areas. However, as large tracts of forest lands were cleared and converted to agricultural crops, many wildlife populations began to decline. Coupled with the removal of vital habitat was a period of unchecked market hunting. Many game populations were devastated. Populations of bear (Ursus americanus), mountain lion (Felis concolor), and American alligator (Alligator mississippiensis) were virtually extirpated. Many of these same populations remain dangerously low even today.

10. Thus the combination of habitat removal and intensive market hunting reduced many wildlife populations in the basin. This occurred quite rapidly and extensively in the Alluvial Plain and to a lesser extent in the Upland Region.

Forest types

11. The vegetation of the Yazoo Basin was initially divided into forest regions by Dunston and a few years later by Lowe. These forest regions were based on topography and geology and followed quite closely the soil classification regions presented by Hilgard during and prior to 1870. In 1921, Lowe produced a map depicting 10 topographic regions for Mississippi; five of these regions occur in the Yazoo Basin. He briefly described the vegetative characteristics of each region. Over four decades later, the Society of American Foresters, described various forest types in Mississippi. Mississippi forests were classified as a part of the Southern Forest Region with the exception of a small projection of the Central Forest Region into the north-central portion of the State.

12. In 1966, another forest type map (Figure E2) was developed by Brown, who described the woodland based on the relative abundance of certain characteristic forest species and divided Mississippi into areas
LEGEND

1. OAK-GUM-CYPRESS
2. OAK-HICKORY
3. LOBLOLLY-SHORTLEAF PINE
4. LONGLEAF-SLASH PINE
5. OAK-PINE

Figure E2. Forest types of Mississippi (from Reference 10)
of the following five forest types: (1) Oak-Gum-Cypress, (2) Oak-Hickory, (3) Loblolly-Shortleaf Pine, (4) Longleaf-Slash Pine, (5) Oak-Pine. The Yazoo Basin, though encompassing less than one-third of the land area of Mississippi, contains four of the five major forest types described by Brown with only the Longleaf-Slash Pine type absent. Nearly all of the State's Oak-Gum-Cypress woodlands are located within the Alluvial Plain. The Upland Region contains the Oak-Hickory, Loblolly-Shortleaf Pine, and Oak-Pine communities. A general description of each forest type in the Yazoo Basin is presented below.

13. **Oak-Gum-Cypress**. The Oak-Gum-Cypress forest type is located between the Mississippi and Yazoo Rivers in the Alluvial Plain. Much of this area has been cleared of forests with remaining woodlands occurring on poorly drained lands too wet for agricultural cultivation. Principal forest species include overcup oak, Nuttall oak (*Q. nuttallii*), sweetgum, tupelo-gum, and baldcypress.

14. **Oak-Hickory**. The Oak-Hickory forest type occurs in the Loess Bluffs bordering the Oak-Gum-Cypress community and also in the northeastern part of the State in a narrow band from Noxubee County north to Tennessee. This forest community consists of such upland hardwood species as southern red oak, cow oak (*Q. michauxii*), chinkapin oak (*Q. meuhlenbergii*), water oak, bitternut hickory (*C. cordiformis*), coast pignut hickory (*C. glabra var. megacarpa*), shagbark hickory (*C. ovata*), and shellbark hickory (*C. laciniosa*).

15. **Loblolly-Shortleaf Pine**. The Loblolly-Shortleaf Pine community occurs on the dry, sandy soils of central and southeastern Mississippi. A small concentration occurs in Tippah County in the northeastern segment of the State. Loblolly and shortleaf pines dominate this forest community, comprising over 50 percent of the commercial trees. Other associated trees include most of those found in the Oak-Hickory type with the addition of black tupelo (*N. sylvatica*), blackjack oak (*Q. marilandica*), and mockernut hickory.

16. **Oak-Pine**. The Oak-Pine type forms an irregular north-south band across the central portion of the Upland Region. This forest community is a mixture of both the Oak-Hickory and Loblolly-Shortleaf
Pine types, consisting primarily of upland oaks. The major hardwoods in this forest type include white oak, scarlet oak (*Q. coccinea*), cow oak, post oak, southern red oak, coast pignut hickory, sweetgum, and black tupelo. Humid areas along minor stream bottoms contain yellow-poplar (*Liriodendron tulipifera*), beech (*Fagus grandifolia*), and magnolia (*Magnolia grandiflora*).

**Wildlife conditions**

17. In terms of wildlife resources, the Yazoo Basin might best be divided into three geographical areas as depicted in Figure E3. A brief description of each area follows.

18. The **Upland Region** is distinctly hilly and comprises the eastern half of the basin. Vegetative communities are principally of the upland hardwoods type (Oak-Hickory, Oak-Pine). The area contains many old fields and other sites of second growth making it quite productive of wildlife. Populations of whitetailed deer (*Odocoileus virginianus*), eastern wild turkey (*Meleagris gallopavo*), and bobwhite quail (*Colinus virginianus*) are increasing.

19. The **Central Alluvial Plain** is bordered on the west by the Mississippi River levee, on the east by the Loess Bluffs, on the north by the furthest extent of the basin, and on the south by an area termed the "Yazoo Backwater." Oak-Gum-Cypress is the primary forest type.

20. The **Central Alluvial Plain** is of prime importance to the wildlife planner because of its severe lack of wildlife habitat. Extensive clearing for agriculture and present-day farming practices have left the area conspicuously bare of woodlots, thickets, and hedgerows. The accepted practices of straight-row plowing, farming up to the edges of water courses, large-field monoculture, and other "clean farming" practices tend to eliminate or degrade wildlife habitat.

21. The **Yazoo Backwater** is situated at the lower tip of the watershed south of an east-west line through the towns of Hollandale, Belzoni, and Tchula and also includes the area northward between the Mississippi River and its eastern levee. While this latter area is not in the Yazoo Basin proper, its proximity to the basin and the wealth of recreational opportunities it affords to basin residents justifies its logical
Figure E3. Wildlife areas of the Yazoo Basin
inclusion in this report.

22. The term "Yazoo Backwater" is used more to indicate a habitat type than a discrete geographical area. Most of the backwater habitat, however, is found in the geographical areas described in paragraph 21.

23. Biologically, the backwater areas are the most productive in the basin. Seasonal flooding and normal surface waters have deposited large amounts of nutrients in these floodways and waterways. The floral communities in these areas are the most lush and diverse in the basin. The Oak-Gum-Cypress forest type (briefly described in paragraph 13) is the dominant community in the backwater areas. This community supports a large number of wildlife species. A partial list of wildlife species found in the Yazoo Backwater area is presented in Table El.

Significant environmental features

24. The Yazoo Basin has a diversity of significant environmental features consisting essentially of undeveloped forests, water bodies, and landforms. The contrasting topography of the Alluvial Plain and the Upland Region has created similarly contrasting environments.

25. The flat Alluvial Plain contains numerous oxbow lakes created by slowly meandering streams. Many of these aquatic habitats are bordered by small concentrations of bottomland hardwoods that provide a contrast to the extensive agricultural fields in the area. Other bottomland hardwoods are scattered throughout the Alluvial Plain in areas generally subject to periodic or permanent inundation. These bottomland hardwood concentrations provide excellent habitat for squirrels, rabbits, deer, and numerous species of avifauna. Four significant areas of bottomland hardwoods are the Sunflower Wildlife Management Area, the Issaquena County Wildlife Management Area, the Yazoo National Wildlife Refuge, and the Hillside National Wildlife Refuge.

26. The Sunflower Wildlife Management area encompasses 70,000 acres in Sharkey, Warren, and Issaquena Counties. Located entirely within the Sunflower Wildlife Management Area is the Delta National Forest. The Delta National Forest is the only recognized wilderness area in the Yazoo Basin. Of the 59,000 acres in the Delta National Forest, approximately 140 acres was divided into three natural research areas in 1943.
One natural area covers 40 acres of virgin sweetgum with the oldest trees ranging in age from 250 to 300 years old. This area contained an estimated 16,606 board feet per acre in 1935. Another 40-acre natural research area consists primarily of overcup oak and Nuttall oak. The oldest trees in this forest community ranged from 200 to 250 years old with over 5,300 board feet per acre represented in the timber stand. The third natural research area encompasses 60 acres. This Green Ash-Sugarberry (Celtis laevigata) forest type contains over 7,300 board feet per acre with the oldest trees ranging in age from 200 to 250 years old.

27. The Issaquena Wildlife Management Area in Issaquena County covers 13,000 acres, and the Yazoo National Wildlife Refuge in Yazoo County covers 12,000 acres. Both of these areas contain excellent wildlife habitat and provide important recreational opportunities to area residents.

28. Another important bottomland hardwood concentration in the Alluvial Plain is the Hillside National Wildlife Refuge. This newly acquired area encompasses approximately 15,000 acres in Holmes and Yazoo Counties and is not presently open for public use.

29. One of the most significant environmental features in the basin is McIntyre Scatters. This extensive tract of bottomland hardwoods and swamp located in Leflore County provides excellent fish and wildlife habitat. Another area containing valuable wildlife habitat is the Eagle's Nest area near Swiftown. This area contains a large colony of alligators, which were imported many years ago.

30. Unlike the Alluvial Plain, the Upland Region has virtually no natural lakes or wetland areas. However, other important environmental features found in the region include the only unique geological system and the only natural landmark in the basin. A 1055-acre segment of the Delta Hills Bluffs in Carroll and Holmes Counties represents the only recognized unique geological system in the basin. The Chestnut Oak Disjunct in Calhoun County, 16 miles north of Bruce, Mississippi, is the only natural landmark in the basin according to the National Registry of Natural Landmarks.
Recent Land-Use Trends

Alluvial Plain

31. The Alluvial Plain of the Yazoo Basin has undergone a tremendous change in the last few decades. Briegleb and McKnight\textsuperscript{16} indicated that the supply of hardwoods over 18 in. in diameter had dropped 40 percent in Mississippi since 1948. They also stated that, because of their productivity, hardwood lands would probably continue to be converted to agricultural use. Beltz and Christopher\textsuperscript{17} found that since the first forest survey in 1932, the proportion of Alluvial Plain land in forest has steadily declined. In 1932, 40 percent of the Alluvial Plain was forested. Between 1957 and 1967, over 425,000 acres of bottomland hardwood forests were cleared\textsuperscript{17} reducing forest land to about 27 percent of the region. The forests cleared between 1957 and 1967 contained 150 million cu ft of growing stock, including one-half billion board feet of sawtimber. Only 30 percent of this wood was sold with most of the remainder bulldozed into windrows and burned.\textsuperscript{17} Forest acreages for 1967 and 1973 are presented, by county, in Table E2. This table indicates an additional 187,100 acres of forests cleared in the Alluvial Plain during this period.

32. This decline in bottomland hardwood acreages is not restricted to Mississippi. In the Arkansas delta region across the Mississippi River from the Yazoo Basin, Holder\textsuperscript{20} determined that approximately 150,000 acres of delta timberlands were cleared each year from 1960 to 1970. Louisiana bottomlands were cleared at the rate of over 110,000 acres per year between 1962 and 1968.\textsuperscript{21}

33. The rapid decline of bottomland hardwood forests has primarily been the result of worldwide demand for soybeans. Approximately 65 percent of the land cleared in the Alluvial Plain between 1957 and 1967 was planted in soybeans.\textsuperscript{17} The value of these bottomlands to wildlife has been widely recognized; documentation of the high-density wildlife in such habitat is extensive and will not be discussed in detail here. Mention of the consequences of the disappearance of this habitat is, however, warranted.
34. The bottomlands (bottomland hardwoods, backwater areas) of eastern Louisiana and southeast Arkansas are virtually identical with those of the Yazoo Basin. The decline of these areas to the west of the Mississippi River is well documented and vividly illustrates the consequences of bottomland hardwoods depletion. Reduction of carrying capacity of bottomland hardwoods in Louisiana, indicated by Yancey, has been quite rapid (Table E3). It is doubtful that the predicted carrying capacities for 1985 will satisfy hunter demands at that time. Holder cites several examples in the Arkansas delta region where bottomland hardwoods of high wildlife carrying capacity were converted to monotypic agricultural areas having only minimal wildlife utility. This conversion has resulted in the reduction of many wildlife species once common to the Mississippi River Valley, such as the common egret (Casmerodius albus). This species, once common in southeast Arkansas, has declined sharply in the last decade as a result of loss of bottomland hardwoods.

35. Loss of bottomland hardwoods as habitat for rare and endangered species in the Mississippi River Valley is also a cause of concern. Certain birds and mammals noted as rare or endangered in a list of such species compiled by the Mississippi Rare and Endangered Species Committee are jeopardized by the loss of their preferred habitat (bottomland hardwoods).

36. In addition to the clearing of timberland for agricultural cultivation, many areas of natural forest land are being converted to monoculture plantations of eastern cottonwood (Populus deltoides var. deltoideae). Unlike many forest stands, cottonwood plantations are very intensively managed against insect and deer damage and are even plowed with heavy disks to control weeds. These row-crop practices result in high timber yields but, like other clean-tilled crops, generate heavy sediment that degrades water quality and aquatic habitats.

37. Documentation of effects of cottonwood culturing on wildlife and wildlife habitat is scattered, and effects are qualitative at best. Widespread opinion is that present techniques diminish an area's value to wildlife. Studies are being conducted at Mississippi State University to help determine the quantitative effects of cottonwood culturing on wildlife.
38. If widescale clearing of bottomland hardwoods continues, and all indications are that it will, this valuable resource may virtually disappear within the next 50 years. The present hardwood resource is such that 8 out of 10 acres will likely change status during this period if measures are not taken to alter present trends.  

Upland Region

39. Land clearing in the Upland Region is occurring at a much slower rate than in the Alluvial Plain. Although forests in the Alluvial Plain declined nearly 13 percent between 1967 and 1973, forest acreage in the Upland Region decreased less than 2 percent for this same period (Table E2). This small decline in forest acreage in the Upland Region is, however, somewhat misleading because intensive reforestation of idle lands practically offset the conversion of forest land to pastures. Between 1962 and 1972, approximately 125,000 wooded acres were cleared and converted to other uses, primarily forage crops.

40. The reforestation of badly eroded areas in the Upland Region began in the late 1940's after continued erosion and ensuing floods had degraded areas to the point where they were considered worthless. Ursic stated that erosion-ravaged north Mississippi was first surveyed by foresters in the early 1930's. The statistics were bleak, indicating that approximately 527,000 acres were totally destroyed by erosion and that an additional 597,000 acres were damaged. Foresters and others were assigned the task of stabilizing the Yazoo and Little Tallahatchie watersheds in 1944 when the U. S. Department of Agriculture initiated the Yazoo-Little Tallahatchie Project (Y-LT). The Y-LT project became the joint responsibility of the U. S. Forest Service and the Soil Conservation Service.

41. The first step in erosion control was to determine the most effective vegetative species to use. Tests were conducted on over 50 annuals, desert shrubs, perennials, and exotics to evaluate various herbaceous species. Several species including African weeping lovegrass (*Eragrostis curvula*), Kudzu (*Pueraria thunbergiana*), and sericea (*Lespedeza cuneata*) were found to be useful; but in the end, the species with the most desirable traits for erosion control in
northern Mississippi was loblolly pine. 28,34,35

42. Loblolly pine has proven to be an ideal erosion-control plant because it survives well, even on badly eroded sites; it grows fast; it requires little maintenance; and perhaps most importantly, it casts more protective litter than other species. 36,37 Ursic and Thames, 38 for example, found that surface runoff and peak flows were greatest from abandoned fields, intermediate from depleted upland hardwood forests, and least from 20-year-old loblolly pine plantations that had been established on eroded farmland. These same trends were later observed by Ursic and Dendy. 39 Over 95 percent of the replanted forest lands have loblolly pine on them. 28 It has been indicated that about 678,357,000 trees have been planted since 1948; 29 over 500,000 acres were planted to pine. 20,40

43. In addition to stabilizing soil conditions, loblolly pine can generate a direct economic return to landowners when properly managed and harvested as pulpwood or sawtimber. 41,42 However, when pine plantations began to reach harvestable size during the 1960's, owners were informed of the possible erosion problems that could accompany poor harvesting practices. 40,42 These forests needed to be harvested in ways that would keep a continuous cover of litter necessary for erosion prevention. 28 Williston 43 further stated that forests protected and unmanaged since the middle 1930's were generally not very productive commercially largely due to cull competition and poor species composition. As a result of concern for possible renewed erosion problems, proper silvicultural and harvesting practices were recommended by Williston. 41,42,44 It was determined that maximum economic return could be realized if landowners initiated thinning practices at 5-year intervals after the stand reached 20 years of age and that sawtimber harvesting could be conducted when the stand was 35 to 40 years old. This would provide early income to the landowner while the stand increased in value each year as it approached sawlog size.

Summary of vegetative trends

44. Vegetative trends in the Yazoo Basin exhibit two definite characteristics. The first characteristic is the rapid decline of
bottomland hardwoods in the Alluvial Plain and the reforestation of idle lands in the Upland Region. The second characteristic is the active conversion of heterogeneous forest communities in both regions to monoculture. In the Alluvial Plain, diverse bottomland hardwood stands are being cleared and converted primarily to soybeans and, in some areas, to eastern cottonwood. In the Upland Region, areas once heavily forested but laid barren by land abuse are now being converted primarily to loblolly pine plantations and, to a lesser extent, forage crops.

45. These changes in vegetative cover are increasing economic productivity but are reducing forest diversification. This decline in habitat diversity decreases ecosystem stability and requires increased energy for maintenance. 45,46

**Endangered or Threatened Biota**

**Flora**

46. Very little work has been done in Mississippi in determining which vegetative species are endangered or threatened. The only list of threatened or endangered Mississippi flora noted in the literature was prepared by the Smithsonian Institute in 1975. 47 This report listed 12 plant species felt by the Institute to be threatened as defined by the Endangered Species Act of 1973 (Public Law 93-205). 48 A list of threatened plants from Mississippi proposed for addition to the lists of threatened or endangered species is presented in the following tabulation.* The report does not provide sufficient information to indicate

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* List compiled by the Smithsonian Institute for consideration by the U. S. Fish and Wildlife Service. 47
presence or absence of these plants in the Yazoo Basin.

Fauna

47. The "Red Book" by the U. S. Fish and Wildlife Service is the principal reference for threatened wildlife in the United States. This document indicates that the southern bald eagle (Haliaeetus leucocephalus) and the American alligator (Alligator mississippiensis) were the first species classified as endangered in Mississippi. Since 1973 when the Red Book was initially prepared, however, populations of American alligator have steadily increased in Mississippi resulting in the proposed reclassification of the animal by the U. S. Fish and Wildlife Service from endangered to threatened.

48. In 1975 the Mississippi Game and Fish Commission (MGFC) published a preliminary list of threatened vertebrates in Mississippi. This publication lists 12 species of amphibians, 18 species of reptiles, 12 species of mammals, and 17 species of birds felt by MGFC to be rare or endangered in Mississippi. An additional 48 faunal species are classified as threatened, status undetermined, or peripheral. (Fish species, though presented in the MGFC publication, are not discussed in this appendix.)

49. Based on the limited range distribution information provided in the MGFC publication, a list of rare and endangered species that might occur in the Yazoo Basin is presented in Table E4.

50. In addition to the two previously discussed data sources, the Mobility and Environmental Systems Laboratory at the U. S. Army Engineer Waterways Experiment Station (WES) is developing a computer data bank to provide an up-to-date information source for endangered and threatened species. The system is expected to be operational in 1976 and will provide valuable information on these important wildlife species.

Resource Economics

Flora

51. Forestry and forest products have traditionally been an
important economic resource in Mississippi. Mississippi forests contained more than 14 billion cu ft of growing stock in 1973. Softwoods, primarily pine, represented more than half of the State's total growing stock. Softwood growing stock increased 10 percent from 1967 to 1973, and hardwoods increased 6 percent during the same time period. This increase in growing stock occurred in spite of a 200,000-acre decrease in total commercial forest land because many slow-growing timber species were replaced by faster growing trees such as cottonwood and loblolly pine.

52. In 1973, there were over 300 wood-using industries in Mississippi (Figure E4). The impact of the forest industry on Mississippi's economy is significant. In 1968, over 64,000 full-time employees worked at timber-based jobs and received an estimated $318 million in wages and salaries.

53. Forest economy also provides important revenue in the Yazoo Basin with over 100 forest industries employing about 30,400 employees in 1967, who earned approximately $114 million. Most of the forest industries in Mississippi consist of sawmills, indicated in Figure E4, and are concentrated in the Upland Region. In addition to the many sawmills in the basin, there are two pulpmills, one located in Warren County and one located in Washington County. These mills produce one-fifth of the total pulpwood capacity of the State.

Fauna

54. The economic aspects of wildlife resources have been touched on in several works. Hunting, a consumptive use of wildlife, is valued at approximately $37 million annually in this basin. This is based primarily on the worth of a day's hunting to the participant. Nonconsumptive uses (nature walks, photography, bird watching) were found to be of higher value to the participants than were consumptive uses on a statewide scale.

55. The available data on expenditures are on a statewide basis. Hunting expenditures were estimated at $22.8 million for 1971-72. Estimates of dollar expenditures were not available for 1973-74, but the total number of hunters and days spent afield increased between
Figure E4. Forest industries in Mississippi (from Van Hooser19)
1971 and 1974, as shown in the following tabulation.

<table>
<thead>
<tr>
<th>Season</th>
<th>1971-72</th>
<th>1973-74</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of hunters</td>
<td>571,157</td>
<td>613,028</td>
<td>+ 41,871</td>
</tr>
<tr>
<td>Days afield</td>
<td>3,592,734</td>
<td>4,035,323</td>
<td>+442,589</td>
</tr>
</tbody>
</table>

56. It is difficult to say much about the fur industry in Mississippi due largely to the lack of consistency in the records. MGFC has no records of fur harvest in the State. There are indications that the North American beaver (*Castor canadensis*) is increasing in number. The increased beaver populations are now a cause for many complaints from landowners in the Upland Region because the beavers dam culverts and can cause localized flooding. There are no estimates on the amount of damage that results.
PART III: INVENTORY OF DATA AND IDENTIFICATION OF PROBLEM AREAS

Existing Data

Vegetative composition and distribution

57. Composition of vegetation in Mississippi and in parts of the Yazoo Basin has been fairly well documented. Lowe began his cataloging of Mississippi plants by presenting some of the prevalent species associated with each of 10 topographic regions in the State.\(^1\) Later, during the 1930's and 1940's, two islands off the gulf coast of Mississippi were analyzed for vegetation composition and plant succession.\(^5\) The vegetation of these islands had little in common with the vegetation of the Yazoo Basin, however. Braun's vegetative description of the Mississippi Embayment Section and the Mississippi Alluvial Plain listed various vegetative species as being present in Mississippi.\(^5\)

58. Four vegetative inventories lacking detailed distribution data were conducted for the entire State of Mississippi. A list of wild flowers of Mississippi was published in 1945 by Batson and Johnston,\(^5\) and Brown published a list of trees common to the State. This list is available from the Mississippi Forestry Commission in Jackson. Rogers\(^6\) and Rogers and Griffin\(^6\) recently reported many additions to the vascular flora of Mississippi and 184 species of bryophytes from central and south Mississippi.

59. Results of the Mississippi Flora Project presently being conducted by Pullen, Jones, and Watson have been and will continue to be published, eventually culminating in a manual of the flora of Mississippi.\(^6\)

60. Vegetative studies in the Yazoo Basin have generally been confined to small segments of the basin. In the late 1950's, Williston described an interesting 70- to 85-year-old baldcypress stand located along Lee Creek, 5 miles east of Abbeville, Mississippi, within the Holy Springs National Forest. Johnson and Price\(^1\) described the vegetation of the Delta National Forest. An annotated list of trees, shrubs,
and vines was published by the Southern Forest Experiment Station in New Orleans for the Bluff Experimental Forest north of Vicksburg in Warren County.  

61. Hopkins described the vegetation of two study areas located between the levee and the Mississippi River as being composed primarily of overstory species such as sugarberry, boxelder (Acer negundo), green ash, and pecan (C. illinoensis). Principal understory woody species were rough-leaved dogwood (Cornus drummondii), deciduous holly (Ilex decidua), and swamp privet (Forestiera acuminata). He also listed several vines and herbaceous species present. Hopkins and Darden, in a study involving wildlife habitat resources in the Delta National Forest, described three forest types within the forest (i.e. Sweetgum-Nuttall Oak-Willow Oak, Sugarberry-American Elm-Green Ash, and Overcup Oak-Water Hickory). They recorded 57 tree, shrub, vine, and herbaceous species in these forest types. Gulf South Research Institute presented a discussion of the vegetation of the Upper Auxiliary Channel area within the Alluvial Plain of the Yazoo Basin; however, inventory data were generally confined to overstory vegetation, and distribution data were cursory and not graphically presented. It was not stated whether the information was based on quantitative or qualitative data.  

62. Although composition of vegetation has been fairly well documented, distribution data are considerably limited. Many studies that determined composition often lacked distribution information. Other data such as the forest type map in Mississippi Trees, which presents both composition and distribution, lack the specificity of two types of information required for effective planning.  

a. First, the breakdown of data often does not lend itself to careful evaluation of the habitat. An example is the State forest type map previously mentioned in which only five vegetative habitats are delineated. These habitats are based on the characteristic forest species present although wildlife habitat evaluation must also consider distribution and abundance of understory vegetation.  

b. Second, the spatial delineations or resolution are often too great to evaluate many Corps of Engineers projects properly.
63. A wildlife habitat map of Mississippi was prepared by the Cartographic Laboratory at the University of Southern Mississippi. The map, prepared from 1972 Earth Resources Technology Satellite imagery, shows habitat types divided into six categories based on predominant forest vegetation and one category for agriculture or open areas. The smallest spatial delineations that can be derived are 1 mile on a side. This map, although designed specifically for wildlife management, does not provide the necessary information to accomplish its objective adequately because of both of the limitations described in paragraph 62a and b.

**Forest management practices**

64. Numerous studies are available from the Southern Forest Experiment Station, various universities, and other research agencies concerning regeneration and timber management procedures for hardwoods and pines. References 70-75 describe some general forest management practices. Particular studies relating to vegetation in the Yazoo Basin are discussed below.

65. Johnson indicated that through improvement cutting techniques [i.e. leaving well-formed, vigorous, desirable timber of species such as sweetgum, green ash, eastern cottonwood, persimmon (Diospyros virginiana), baldcypress, and red mulberry (Morus rubra) and eliminating undesirable species and the accompanying competition], resultant stands would be more vigorous and productive. Landowners in the Loess Bluff area were encouraged to upgrade forests on their land by promoting the growth of southern red oak, Shumard oak (Quercus shumardii), yellowpoplar, white ash (F. americana), cottonwood, and black walnut (Juglans nigra). Other species that grow well in the region and that landowners were encouraged to grow were American basswood (Tilia americana), sweetgum, chinkapin oak, American elm (U. americana), blackgum (black tupelo), cucumbertree (M. acuminata), sassafras (Sassafras albidum) and sycamore (Plantanus occidentalis).

66. Williston and Huckenpahler were concerned with underplanting in the hills of north Mississippi. They found that loblolly pine, white ash, and shortleaf pine were good underplanting species,
especially when release from hardwood competition is accomplished.

67. Broadfoot determined that the famed Sharkey clay soils were quite productive with Nuttall oak, overcup oak, green ash, persimmon, hackberry (*C. occidentalis*), American elm, and water hickory growing well on flats and sweetgum, willow oak, and water oak doing well on ridges. Broadfoot also found that shallow-water impoundment during winter and spring increased hardwood production by about 50 percent. Tree species representative of the impoundment study were sweetgum, green ash, Nuttall oak, willow oak, overcup oak, hackberry, American elm, cottonwood, water hickory, honeylocust (*Gleditsia triacanthos*), persimmon, and red maple (*A. rubrum*).

68. Johnson determined the effect of grazing by cattle on a bottomland hardwood forest in the Alluvial Plain. Trees present were rated in regard to commercial value as follows:

- **High** - green ash, Nuttall oak, willow oak, sweetgum, and persimmon.
- **Medium** - American elm, hackberry, overcup oak, and red maple.

Trees most preferred by cattle were American elm, hackberry, mulberry, boxelder, and green ash. Of these, green ash, hackberry, and American elm were of commercial value. It was determined that cattle could cause damage to small hardwoods and, therefore, should be managed carefully in that forest type.

69. During the late 1950's and 1960's, interest in cottonwood cultivation increased markedly because of declining production of other bottomland hardwoods. Because of this interest, many experiments were conducted to ascertain genetically superior clones in growth, phenology, and disease resistance in cottonwood. A few cottonwood silviculture studies were conducted by Johnson, Broadfoot and Bonner, McKnight and Biesterfeldt, McKnight, and Baker and Blackmon. Four other papers on cottonwood silviculture were presented at the 19th Annual Forestry Symposium in Baton Rouge, Louisiana, in 1970.

70. Most of the previously discussed forest management studies have been concerned with forest species common in the Alluvial Plain. In the Upland Region of the Yazoo Basin, considerable effort has been
put forth in studying effects of loblolly pine on erosion control. Studies concerning this aspect of forest management and other related topics are presented in the following section.

**Hydrologic studies**

71. The literature on hydrologic studies covers a wide spectrum of forest-related topics including effects of prescribed burning on runoff and sediment distribution, effects of forest cover types on runoff and erosion, effect of forests on aquifer recharge and depletion, and erosion control by forest plantings.

72. Ursic\(^{92}\) evaluated the hydrologic effects of prescribed burning of abandoned fields in northern Mississippi. He determined that prescribed burning increased stormflows, overland flows, peak discharges, and sediment production for at least 3 years on grass-covered watersheds with well-drained soils. Similar results were determined on soils with a shallow fragipan except that stormflow volumes were not influenced. A similar study was conducted on two wooded watersheds in northern Mississippi.\(^{93}\) Hydrologic effects of prescribed burning and deadening of hardwoods with herbicides were evaluated. The results were similar to those found for abandoned fields.\(^{92}\)

73. Erosion and runoff from various cover types and land uses were evaluated for 16 watersheds in northern Mississippi by Ursic and Dendy.\(^{39}\) One watershed consisted of pasture with three replications containing cultivated lands planted with corn, abandoned fields with native grasses, depleted stands of upland hardwoods, abandoned lands planted in loblolly pine, and forest of mature shortleaf pine and hardwoods. Annual sediment yields and average concentrations of sediment per unit of runoff decreased in the order: corn > pasture > abandoned fields and depleted hardwoods > pine plantations and mature pine-hardwoods. Runoff decreased in the order: corn and pasture > abandoned fields > depleted hardwoods and pine-hardwood pine plantations. The study results indicated large variation in annual runoff and sediment production attributable to land use and cover types. Soil characteristics also influential run off with watersheds of loessial soils having greater runoff than those containing both loess and coastal plains soils.
Effect of soil on sediment yields was not consistent for all cover types.

74. Ursic and Thames evaluated surface runoff and peak flows on abandoned fields, depleted hardwood forests, and loblolly pine plantations. Their results were similar to those of Ursic and Dendy as previously discussed.

75. Average annual water and sediment yields were evaluated on eight small pine-covered watersheds in relation to soil characteristics. The researcher demonstrated the importance of soil information for predicting hydrologic behavior and felt that runoff and sediment yields could be predicted from annual precipitation and soil survey information.

76. Influence of vegetative cover on groundwater recharge has been briefly discussed by Ursic and Duffy. These researchers felt that proper manipulation of stocking densities in pine plantations could increase groundwater recharge and that any reduction in stocking density would tend to leave a higher reserve of soil water. This idea is supported by Rogerson, who determined that interception loss could be reduced 1 area inch for every 20-sq-ft reduction in basal area per acre of pole-size loblolly pine.

77. Species composition, like stand density, can have considerable influence on groundwater supplies. Swank, Goebel, and Helvey determined that net loss to interception by 10-, 20-, and 30-year-old loblolly pine averaged 19 percent of the annual rainfall, whereas interception loss from mature hardwoods was estimated to be only 11 percent. Swank and Douglas, while working in the southern Appalachian area, demonstrated that conversion from mature mixed hardwoods to eastern white pine (P. strobus) reduced annual streamflow 8 area inches only 15 years after the pine had been planted. Although forest vegetation could have some impact on streamflow and groundwater recharge, Ursic felt that reduced water yields would not create a widespread problem in the Coastal Plain area of the United States.

* One area inch is equivalent to one inch over the area of the watershed.
78. Erosion control through vegetative plantings has been intensively studied, largely as a result of land-abuse practices like those experienced in the Upland Region of the basin. Many vegetative species were evaluated to determine erosion control characteristics. As discussed in paragraph 42, after numerous tests, it was determined that loblolly pine met most of the requirements as an ideal erosion-control plant. Much of the research on which current practices are based for use of loblolly pine on eroded sites has been reported by Ursic.

79. Most of the hydrologic studies discussed were conducted in the Upland Region of northern Mississippi with little attention given to Alluvial Plain forests. Most hydrologic studies in the Alluvial Plain were concerned with the effects of flooding on growth and survival of forest vegetation. In one study near Greenville, Mississippi, winter and spring rainfall were artificially impounded in two areas until 1 July when waters were drained. Both areas contained well-stocked, uneven-aged hardwood stands about 50 years old. Water depth was approximately 3 ft. The 8-year study indicated that impounding water increased radial growth of pole- and sawtimber-size trees of all species sampled. The average increase in radial growth for all species was slightly over 50 percent. Another study in the Steele Bayou and Yazoo River backwater area north of Vicksburg, Mississippi, determined diameter growth of dominant hardwoods to be 50 to 100 percent greater in flood than in nonflood years. It was pointed out, however, that depth and duration of flooding, chemical properties of soils, and species and age of trees can have varying effects on response of vegetation to flooding. Classification of the flooding tolerance of many trees has been conducted by Hall, Penfound, and Hess and Kennedy and Krinard.

80. An indirect effect of flooding is sedimentation. Sedimentation of sand deposits up to 5 ft deep has been shown to cause appreciable damage to a 2-year-old plantation of cottonwood. However, seedlings from cottonwood, baldcypress, tupelo (Nyssa spp.), and black willow (Salix nigra) can withstand only moderate siltation. Where sedimentation retards soil aeration, other seedlings can also be damaged.
81. Information for most of the hydrologic studies previously discussed was compiled by the Forest Hydrology Laboratory at Oxford, Mississippi, and the Southern Hardwoods Laboratory at Stoneville, Mississippi. Both laboratories are maintained by the Southern Forest Experiment Station.

Forest economic data

82. Information concerning forest production, acreages, growing stock volumes, harvest data, and identification and location of forest industries is readily available from the Southern Forest Experiment Station in New Orleans, Louisiana. Some recent publications include those by Bertelson, Christopher, and Van Hooser. Harvest and survey data have been compiled every 10 years until 1967 when 5-year intervals were initiated. Information is presented in tabular form for each county. Severance tax data are available from the State Tax Commission in Jackson. The most recently compiled severance tax data were for calendar year 1974. Reports present sufficient information to indicate trends in growing stock, harvest, and economic utility. Data concerning number of owners of timbered land and landowners with over 500 acres of land are available from the Mississippi Forestry Commission in Jackson. These data are in tabular form for each county in the State.

Wildlife distribution, relative abundance, and species occurrences

83. There are no data of an inventory nature* available about the abundance or distribution of Mississippi's wildlife except for a very few game species.

84. A joint Federal and State effort in 1943 termed "The Survey Project" was the first and only comprehensive biological survey of a statewide scale in Mississippi. The project was a survey-level (qualitative) investigation resulting in descriptions of a morphological, ecological, and general distribution nature. The data are severely lacking in uniformity and specificity largely because it was written from a naturalist's point of view.

* "Inventory" used herein denotes a routine, low-biased, uniform collection of data on a statewide or basinwide scale.
85. There are many general accounts of the occurrences of species, their habits, and habitat preferences. MGFC has documented the occurrences of rare and endangered species and is presently engaged in an effort to map these and more recent occurrences. Robert Noble, former biologist for MGFC, touched upon relative abundance and distribution of the white-tailed deer in his work on the reproduction of the animal. This work, too, deals with abundance on the most general terms; the distribution information is somewhat valuable because it covers a longer time frame than most references. Noble's work is a valuable source of information about the white-tailed deer's potential for productivity, a property most valuable, if indirectly, to the planner.

86. The wild turkey is another species whose life history has been dealt with in recent studies. This work, however, is not of inventory nature, and many of the results have not been extrapolated to the Yazoo Basin.

87. MGFC records of annual game harvest give some indication of the condition of various wildlife populations, but the data are limited to less than a dozen species and the source data are highly dubious.

Wildlife habitats

88. Descriptive data on habitats in Mississippi exist, such as lists of species expected to occur and descriptions of forest communities. However, a severe deficiency in existing data is the lack of discussion of the interactions between the various components of the ecosystem in the basin. There is also a lack of inventory-type data about habitats similar to the lack of wildlife populations information; the forest industry is a notable exception. In order to maintain their own economic viability, these private firms must keep an up-to-date account of resources on land, both amounts and condition. Much of this information (stand age, size, acreage, distribution) never leaves company files or computer banks such as those at Mississippi State University.

Wildlife-oriented recreation

89. There is an effort in the State government to develop
recreational opportunities in Mississippi. This trend has spawned studies such as the "Outdoor Recreation Plan; Resources and Opportunities in Mississippi." This study was enacted to survey the recreation needs and potential, as well as the present opportunities in the State. The authors of the publication do a reasonably good job of compiling data about existing facilities at the State and Federal level. Consumptive uses of wildlife are expressed in license sales, hunter days, and harvest records. Nonconsumptive wildlife recreation is not expressed in quantitative terms.

90. An economic survey of wildlife recreation, completed for Mississippi in 1964 by Georgia State University, characterized the uses of wildlife at the time of the survey. The primary data in this investigation were collected by household interviews. Resultant data consist of value received by the user from wildlife-oriented activities and value required to give up wildlife-oriented activities. Both of these categories were expressed in numbers of days and dollars. The survey did not examine the supply of recreational opportunities or the actual economics of wildlife recreation, merely user projections.

Resource evaluation and inventory

91. Dr. Frank Miller at Mississippi State University has been working with several evaluation schemes in studies to be used in conjunction with construction of the Tennessee-Tombigbee waterway. Two of the studies use remote sensing, which in one case is integrated with ground truth information.

92. The first of these studies, the application of remote sensing to the identification of potential recreational sites along the Tennessee-Tombigbee waterway route, involves an air photo interpretation scheme to delineate and rate potential forest and wildlife recreation sites. The criteria for evaluation are specific to the study areas and were developed on the basis of a predicted specified use.

93. The second investigation, an ecological study of the Tennessee-Tombigbee waterway, is an overall examination of the biota of the area. Field and remote-sensing techniques were integrated to
gain quantitative knowledge of many fauna and flora. While some procedures are debatable, the work is an excellent example of a comprehensive survey of terrestrial biota.

94. The U. S. Forest Service is presently evaluating a Wildlife Habitat Evaluation Program (WHEP). WHEP combines wildlife habitat requirements with an evaluation of existing conditions. This combination is designed to provide a relative numerical habitat rating for each wildlife species analyzed or for each set of habitat conditions. The system incorporates three major steps in its evaluation. Step one requires identification of key habitat elements for each wildlife species studied; and input is obtained through consultation with wildlife experts, each habitat is rated according to its importance to a particular species. The second step consists of collection of field samples stratified by similar physiographic and vegetative ecosystems. These field samples identify numerous habitat characteristics, which are also categorized by relative importance. Step three involves computerized analysis using field data and the biologists' evaluation of key habitat requirements. Each field plot is rated for each wildlife species.

95. Presently the system is being worked in the Alabama River Basin, and a final report is expected by the middle of 1976. Other ongoing studies are being conducted along the Texas gulf coastal area, in the Ouachita River Basin, and in the Loess Bluff area of the Yazoo Basin.

96. The U. S. Forest Service also has a computerized mapping system that is capable of overlaying different types of information. Each map is formed by a binomial coding system capable of illustrating information such as county lines, soil associations, forest locations, and certain types of land use.

97. A preliminary habitat evaluation system is presently being developed and evaluated by the U. S. Army Engineer Division, Lower Mississippi Valley (LMVD), in Vicksburg, Mississippi. The system is proposed as a methodology for environmental impact assessment and is based on a series of curves that describe key parameters of major
habitat types. Each curve is used to transform raw data collected during the environmental assessment phase into an index value between 0.0 and 1.0. Each parameter is assigned a weighted value based on its relative importance in describing habitat quality. The product of these two terms yields a weighted index value for each parameter. The quality of each particular habitat type is then determined by summing the weighted index values.

98. The habitat evaluation program is being implemented in the Wolf River area by the U. S. Army Engineer District, Memphis, and in the lower Yazoo Basin by the U. S. Army Engineer District, Vicksburg (VXD). Both studies are pilot programs to evaluate the usefulness of the LMVD program.

99. The Soil Conservation Service in Jackson, Mississippi, published the results of a study in June 1975 that attempted to address the requirements in the Water Resources Council's "Water and Related Land Resources; Establishment of Principles and Standards for Planning." The report contains a wealth of information on all resources in the Yazoo Basin.

100. LMVD has aerial coverage of the entire division. The photos were taken in November 1974 at a scale of 1:120,000. VXD has copies of these photos in color at a scale of 1:62,500. The U. S. Fish and Wildlife Service in Vicksburg, Mississippi, also has aerial coverage (scale 1:20,000) of the three states covered by VXD. The aerial photos were taken in 1951 for the purpose of delineating and classifying wetland areas in accordance with the system developed by the Wetlands Classification Committee of the Fish and Wildlife Service, which describes 20 major wetland types. The aerial photos are grouped by state and subdivided by county within a state. These photos, when compared with the VXD 1974 photos, indicate land-use changes that have occurred in the Yazoo Basin during the last two decades.

Impact studies

101. The effect of man's activities on the environment is now a most important factor in the evaluation of many federally funded projects. The qualitative effects of many Corps activities are fairly
well known, but long-range resource planning must also be based upon quantified information about these impacts.

102. The Corps of Engineers is presently engaged in an extensive program, the Dredged Material Research Program (DMRP), to gain knowledge about the short- and long-term effects of dredged material disposal on the environment. The program is a significant effort by the Corps. However, the program is somewhat limited in its treatment of inland disposal operation.

103. The effects of channelization of rivers have been documented by Funk and Robinson in their work on the Missouri River. Statements were made in this work about selected wildlife species:

"The loss of suitable habitat is the principal limit to production of deer along the river" (page 33).

"The habitat requirements of the species [otter] are not well known but its decline in abundance parallels the loss of slough and backwater habitat in the Missouri River" (page 33).

"The abundance of other furbearers and upland game mammals and birds...has been reduced by the loss of habitat associated with river channelization" (page 38).

These and other statements were based on admittedly piecemeal data, and are only general and qualitative conclusions about the impact of channelization.

104. One of the effects of man on the environment that may be intentional or accidental is the damage caused by fire. Aside from the voluminous amount of work done on the effects of fires in other areas in the Nation, two studies by S. J. Ursic92,93 of the Southern Forest Experiment Station, U. S. Department of Agriculture, deal with prescribed burning in Mississippi. These works help gain insight into the hydrologic effects of prescribed burning on two wildlife habitat types: abandoned fields and upland hardwoods. While narrow in scope, these two studies are highly valuable to the long-range planner.

105. A study presently being conducted by Dr. David Wesley at Mississippi State University will apparently yield some extremely valuable data about the effects of cottonwood culture practices on wildlife and wildlife habitat.112 The investigation is scheduled for
completion in 1977 and should provide the planner with very useful quantified information about the environmental effect of this widespread practice.

106. A study dealing with the basic life history and habits of the wild turkey is also ongoing at Mississippi State University.68 This study provides some basic data as to habitat preferences and utilization by this species.

107. The effects of agricultural chemicals on terrestrial wildlife in the Yazoo Basin have been largely overlooked. Two studies115,116 discuss the effects of pesticides on various faunal species and on birds, respectively. Ferguson115 concluded that resistance to biocides may be building in some species. Walley116 discussed the fate of DDT after ingestion by birds. Other than scattered statements about possible resistance to agricultural chemicals, the little literature deals with significant effects of biocides on wildlife.

108. On a more general note, the impacts of man's activities on the physiographic region called the "Delta" have been discussed for Mississippi, Arkansas, and Louisiana.13,20,21 Most of the statements in these publications are qualitative and give the resource planner little information useful for determining the significance of various planning alternatives. Some sample statements follow:

"Over large areas, habitat for fishes and wildlife is gone, and the quality and aesthetic appeal of the land has depreciated" (Holder, page 42).20

"Based upon all of the information available at this time the outlook for maintaining major stands of hardwoods in the delta region in the years ahead is extremely dismal. Gigantic land clearing operations in recent years have converted many hundreds of thousands of acres of hardwood forests to fields that are now being utilized for the production of agricultural crops and livestock. As the acreage in hardwood forests has declined the carrying capacity for wildlife has also diminished proportionately" (Yancey, page 3).21

Data Gaps

Impact studies

109. The authors are aware of only one program studying the
long-range impacts of Corps of Engineer activities: the DMRP at WES. Extensive field studies are being conducted to help assess the environmental impacts of various disposal techniques. Unfortunately, the DMRP has not conducted studies in areas similar to those found in the Yazoo Basin. Studies that provide criteria for quantifying impacts of other Corps activities are absent.

Biota distribution and abundance data

110. Spatial species distribution data are inherently area-specific, i.e. obtained only through work in the Yazoo Basin itself. The distribution data available for terrestrial species (both floral and faunal) in the basin are insufficient for planning at the State and local level.

111. The abundance of various species can be determined in a more indirect fashion provided habitat distribution data are available. Abundance data need not initially come from the basin. A per-area abundance measurement from other areas can be combined with the distribution and abundance of similar areas (habitats) in the Yazoo Basin to estimate the abundance of various species in the basin. The accuracy of the estimation, of course, depends upon many things such as how similar the various habitats outside the basin are to those within, the accuracy of the original abundance data, and the accuracy of data about the habitat within the basin. Presently, careful habitat delineations in the basin are lacking.

Data bias

112. Biases in the present data are mentioned not as a data gap but as a limitation inherent in most data that must be reduced prior to use in the planning process. The bias of a particular set of data refers to its orientation toward a particular discipline. The interdisciplinary nature of environmental planning demands that these biases be applied in a controlled manner to common data.

Problem Identification

113. The following problem areas were noted during review of
existing literature and contacts with Federal, State, and local agencies. These problems are closely related to terrestrial resources and in no way should be construed as representing all the problems in the Yazoo Basin. Such problems as flooding, degradation of water quality, and erosion and sedimentation are also important problems in the basin. However, these problems and others are discussed in detail in other sections of the report. The major problems in the Yazoo Basin related to terrestrial resources are briefly discussed below.

Habitat removal

114. Between 1957 and 1973, over one-half million acres of bottomland hardwoods were cleared in the Alluvial Plain; most of the land was converted to soybean cultivation. Other cleared areas not cultivated in soybeans have been converted to cottonwood plantations, which, though still in timber production, provide considerably fewer wildlife benefits than the original forest stand. The following two problems discussed are partially a consequence of bottomland hardwood clearing.

Limited recreational opportunities in the Alluvial Plain

115. Recreation areas in the Alluvial Plain are generally confined to a few remaining bottomland hardwood concentrations such as the Delta National Forest, the Yazoo National Wildlife Refuge, and the Issaquena Wildlife Management Area. Coupled with the direct elimination of wildlife habitat through land clearing is the development of hunting clubs. These clubs are tying up potentially valuable recreation and therefore limiting the use of the land by the general public.

116. Degradation of water-based recreation areas and destruction of important wildlife habitat areas such as wetlands are occurring in areas converted from bottomland hardwood forests to clean-tilled row crops. The degradation is the result of sedimentation induced from accelerated erosion.

Inability of forests to satisfy anticipated needs

117. This problem is a result of past timber-harvesting practices in which the high-quality timber was removed. The cutover forests that remained had poor species composition and cull trees. Present forest
management practices are increasing timber yield per acre, but total commercial forest acreages in the basin showed an overall decline of nearly 6 percent between 1967 and 1973.
PART IV: RECOMMENDATIONS

118. This section is a discussion of final recommendations that will serve to eliminate certain gaps in the existing data, aid in the evaluation of man's impact on the environment of the Yazoo Basin, and give some initial direction to the Yazoo Basin study.

119. The authors recognize that there are certain types of studies necessary to planning that do not appear to fall within the jurisdiction of VXD. These studies include:

a. Distribution of game and nongame wildlife species in the basin.
b. Abundance of game and nongame wildlife species in the basin.
c. Wildlife food and habitat preferences.
d. Factors affecting mortality and natality for various species within the basin.
e. Nutrient flow, growth rates, and other data that would help determine the rates and mechanisms of plant succession in the basin.

Although some of these data have been collected by various groups, much has not been, as discussed in "Data Gaps."

120. VXD should continue to cooperate with agencies whenever possible so that all groups in the Yazoo Basin, both public and private, are aware of each other's needs. This awareness tends to reduce duplication of effort in acquiring new data and allows all agencies to design programs that will be complementary. The Resource Information System (RIS) discussed in the main text is one vehicle for cooperation. The following recommendations are discussed in order of priority with the first recommendation of highest priority. The size, scope, and level of funding of each will be dependent upon the needs of VXD; general frameworks, however, are presented.

Wildlife Habitat Inventory

121. An inventory of existing wildlife habitat should be conducted immediately. The initial portion of the inventory should concentrate
on the Alluvial Plain because conversion of wildlife habitat to other uses is occurring much more rapidly here than in the Upland Region (paragraph 44). The inventory should consist of map overlays covering the entire basin, along with measurements (both areal and, where applicable, linear) of data on each overlay.

Justification

122. The management of any resource requires knowledge of existing conditions. This knowledge of baseline conditions allows the examination of past trends, projection of future conditions, evaluation of proposed impacts, and selection of planning alternatives. The system of accounts as outlined in the Water Resources Council's "Principles and Standards" calls for assessment of impacts of various planning alternatives. Without knowledge of existing wildlife habitat, these accounts cannot be adequately computed; impacts cannot be addressed; future conditions cannot be projected; and planning alternatives cannot be chosen in a meaningful manner.

123. Land-use maps of various data have been and are presently being developed for all or part of the Yazoo Basin. However, maps depicting the entire basin (i.e. forest type maps) lack the specificity needed to evaluate effectively vegetative resources in smaller areas such as those required by most Corps of Engineers projects. This lack of specificity is also often observed on land-use maps of small areas such as those presently being developed by the Mississippi Research and Development Center (R&DC) in Jackson, Mississippi. The ongoing R&DC land-use map is being developed by townships and divides forest types into coniferous, deciduous, mixed, and other. This breakdown of vegetation makes it difficult to determine or evaluate wildlife habitat, which is a necessary portion of Corps of Engineer project evaluation.

124. The proposed inventory and map, if properly designed, could be a useful tool in the evaluation and development of recreation sites such as those bordering the four Corps of Engineers reservoirs in the basin. The inventory and cover map could also be useful for evaluation of proposed mitigation lands and, when the Office, Chief of Engineers, finalizes the criteria for wetland determinations, could be used to
delineate wetland areas. Graphically locating wetland areas would be beneficial to the Corps of Engineers permit program as authorized under Section 10 of the River and Harbor Act of 1899 and Section 404 of the Federal Water Pollution Control Act Amendments of 1972. Under Section 404, the Corps of Engineers permit program is required to evaluate the cumulative effects of permitted actions and the proposed map and inventory data could be used to aid in this determination.\textsuperscript{117}

125. The U. S. Fish and Wildlife Service and the National Marine Fisheries Service are presently attempting to determine "critical habitat" for 108 currently listed endangered species as defined in the Endangered Species Act of 1973.\textsuperscript{119} When criteria are developed for critical habitat, these criteria should be incorporated into the land cover inventory and map. The location of critical habitat on a map would be extremely beneficial in planning future Corps of Engineers projects.

\textbf{Methodology}

126. "Wildlife habitat" is a term difficult to define. Theoretically it encompasses the surface of the entire globe, and the atmosphere surrounding it. For purposes of practicality, though, the habitat components that are to be included in the inventory are vegetation, surface waters, and cultural features that have significant effects on the basin's wildlife. The following are examples of the types of data to be collected and mapped, as well as some specifications for the wildlife habitat inventory.

127. **General types of data desirable in wildlife habitat inventory.**

\textbf{a. Upland habitat}

(1) Barren soil and rock
(2) Plantations (coniferous)
(3) Plantations (deciduous)
(4) Pasture and grassland
(5) Shrubs
(6) Young trees (natural), deciduous
(7) Young Trees (natural), coniferous
(8) Mature trees (live, natural), deciduous
(9) Dead trees  
(10) Mixtures of the above  

b. Surface waters  
(1) Rivers  
(2) Streams  
(3) Natural ponds, lakes, and open water  
(4) Man-made ponds and lakes

c. Wetlands  
(1) Emergent grasses  
(2) Flooded shrubs  
(3) Flooded live deciduous trees  
(4) Flooded dead trees

128. **Wildlife habitat inventory specifications.**  

a. **Coverage:** basinwide  
b. **Data source:** aerial photographs  
c. **Data collection techniques:** air photo interpretation, ground truths, other records  
d. **Final product:** transparent map overlays with data tabulations  

(1) Overlays:  
(a) Hand drafted from data delineated on aerial photos  
(b) Use U. S. Geological Survey or similar quad maps as base maps  

(2) Tabulations:  
(a) Grid cell by grid cell data summarization  
(b) Suitable for entry into RIS

e. **Measurements:**  
(1) Area: all cover types  
(2) Linear: hedgerows, rights-of-way, habitat "edge effects," stream and river miles, shoreline, etc.  
(3) Point data: access points to waterways and large natural areas, developed recreational sites, deer camps, etc.

f. **Inventory scale:** 1:24,000 overlays  
g. **Smallest mapped units:** 1 acre
129. It is important to remember that the lists in paragraph 127 and 128 are only an example of what might be collected. The actual items to be included in a habitat inventory and their specificity, classification, and level of accuracy will be determined during a design stage of the actual study. The design of the wildlife habitat inventory should be conducted at the same time as, and in close coordination with, the design stage of the RIS (see Volume I).

130. The data collection for this inventory must be closely coordinated with data-collection efforts of other disciplines in order to maintain consistency in scale, accuracy, and comparability over time. The habitat inventory data could be entered into the RIS for correlation and comparisons with all types of resource data.

131. The most economical and accurate method for habitat data collection is by mapping the data directly from air photos. Air photo interpretation is also the most efficient way of collecting much information about other resources. This implies that the wildlife habitat inventory might best be included in an overall resource inventory as described in the initial inventory stage of the RIS. This inclusion of the habitat inventory in the RIS effort will require little or no additional funding beyond that already discussed for the RIS.

Alternate methodology

132. Several alternatives to the recommended methodology for conducting the wildlife habitat inventory previously described were considered. Appendix E' gives discussion of an alternative methodology that would provide a much more detailed inventory of the basin than that recommended but with a concomitant increase in the work required. Although the amount of detailed data that would result from this alternative is not deemed necessary for the overall basin inventory, the methodology is included as an example of the type of studies that may be required for evaluating specific sites, especially for identifying endangered plant species, during the impact assessment phase of the Yazoo Basin Study.
Long-Range Impact Studies

133. A series of long-range impact studies for selected civil works projects in the Yazoo Basin should be initiated to assess, in quantitative terms, the impact of Corps of Engineers field operations on the biological communities in the vicinity of a given project. The studies should begin with a baseline study prior to any construction operations. Monitoring of during-construction conditions should ensue, followed by a long-term measuring program to assess effects that may appear later.

Justification

134. Little work has been conducted in VXD to determine the long-term effects of Corps of Engineers projects on the environmental quality or economic development of project-affected areas in the basin. Studies in the past have generally been preconstruction environmental inventories and assessments of existing conditions with a "crystal ball" approach to future effects. The implementation of long-term impact studies on various Corps of Engineers projects would help quantify project impacts and give substance to future evaluations. Results of the various studies could then be used to establish criteria for assessment of impacts of similar projects in other parts of the Yazoo Basin.

Methodology

135. The impact studies should be implemented on projects that exemplify particular types of activity (e.g. dikes, revetments, levees, channel improvements, etc.).

136. The suggested methodology is outlined below:

a. Literature search of pertinent impact studies and impact assessment methodologies to identify candidate activities

b. Selection of projects for study

c. Initiation of individual studies consisting of

   (1) Literature search for site-specific data on the particular area

   (2) Baseline study of at least 6 months to include one growing season prior to construction
(3) Construction phase monitoring
(4) Long-term monitoring for at least 2 years (two growing seasons after completion of construction)
(5) Report writing

d. Coordination of all studies that will occur throughout the impact study program
e. Interfacing the results of these impact studies with the RIS to allow correlation of impacts with other elements in the basin environment

Habitat Protection

137. VXD should discourage the extensive clearing of the remaining natural habitats of the Yazoo Basin. VXD should also seek to encourage the development of woodlots, thickets, hedgerows, greenbelts along streams, and other natural habitats in the central Alluvial Plain.

Justification

138. The loss of bottomland hardwoods is an important problem in the Yazoo Basin, particularly in the Alluvial Plain where wetlands and woodlands are being cleared at an alarming rate. MG J. W. Morris, formerly Director of Civil Works, reflected the U. S. Army Corps of Engineers' concern for wetlands when he stated that Corps efforts to protect wetlands must continue to get highest environmental priority.

139. As wetlands and woodlands are drained and cleared for agricultural production, many important economic and environmental changes occur. One advantageous effect is that direct economic return from the land area is usually increased. There are, however, numerous direct and indirect adverse effects that result when these hardwood forests are converted to agricultural fields. With the removal of remaining bottomland hardwoods comes the decline of many wildlife species such as squirrels, ducks, rabbits, and white-tailed deer. The decline of these species results in a similar decline in recreational opportunities for hunting. Wetland areas, in addition to providing habitats for wildlife, serve as nursery grounds for many fish, thus reduction of wetlands has an adverse effect on commercial and sport fishing in
the area. Furbearers such as beaver, raccoon, and mink also use wetland areas and economic return from harvest of these animals is reduced where wetlands are destroyed.

140. In addition to providing habitat to wildlife, wetland areas serve as natural catch basins where surface runoff collects and recharges subsurface water supplies, thereby providing important flood-control and water supply benefits. This catch basin effect also allows suspended material from surface runoff to settle out and, therefore, helps improve stream water quality and aesthetic appeal and can reduce the frequency of operation and maintenance dredging. Clearing of woodlands and greenbelts results in increased erosion and water turbidity. Clearing also eliminates timber production from a timber base that, according to the U. S. Department of Agriculture, will not be able to supply projected forest product demands in the basin after the year 1980.

141. In an effort to improve water quality, recreational opportunities, and nonstructural flood control and to satisfy permit responsibilities in Section 404 guidelines of the Federal Water Pollution Control Act Amendments of 1972, the Corps of Engineers must work closely with other Government agencies to curb the steady decline of wetlands and woodlands in the Alluvial Plain. This problem can be approached from two directions: (1) discourage the destruction of wetlands and woodlands by retarding agricultural clearing and (2) encourage the preservation of wetlands and woodlands by providing economic incentives to landowners for maintaining these areas in their current condition. The Corps of Engineers cannot, by itself, accomplish such a monumental task but may, through coordination with other agencies, provide valuable assistance. A discussion of some possible methods follows for each suggested approach.

**Methodology**

142. **Discourage the destruction of wetlands and woodlands by retarding agricultural clearing.** The Corps of Engineers can have considerable influence in retarding clearing of wetlands through its Section 404 permit program. This program might also retard land
clearing along streams in areas below the ordinary high-water mark.

143. Destruction of wetlands and woodlands should be discouraged by prohibiting land clearing to be used as an income tax-deductible expense. This alternative is not a Corps of Engineers responsibility and would have to be achieved through Federal legislation.

144. Floodplain management is another alternative that might also inhibit wetland and woodland clearing. This important resource management tool often encompasses more than simply preservation of wetlands and woodlands.

145. Encourage the preservation of wetlands and woodlands by providing economic incentives to landowners for maintaining these areas in their current condition. The Corps of Engineers would have little direct influence in providing economic incentives to landowners other than perhaps through direct purchase of fee title or easements for mitigation lands. However, the U. S. Department of Agriculture, under the authority of four similar bills collectively referred to as the Water Bank Act (PL 91-559), can pay landowners a per-acre fee for preserving designated wetlands. This program, initiated in 1972, is presently being implemented in Leflore County where landowners are receiving approximately $5.00 per acre annually for preservation of over 10,000 acres of wetlands. This is the only area in the basin where this legislative action is being implemented.

146. Some objectives of the Water Bank Acts include flood control, improved water quality, and reduction of stream sedimentation. These objectives are important considerations in Corps activities and, therefore, could serve as a basis for interagency coordination in conserving wetlands. The role of the Corps in aiding the U. S. Department of Agriculture in this program could be in the identification and location of wetlands. Since the Corps is already charged with permit responsibility in wetlands, dissemination of wetland information to the U. S. Department of Agriculture could aid in identifying more areas that would qualify for the program.

147. A program that has some tremendous potential for protection of natural habitat is a "game farm" program presently being initiated
jointly by MGFC and the Soil Conservation Service. The program, aimed at enhancing farms for wildlife and providing hunter access to private lands is presently only in the discussion stage. Future development meetings for the program have been planned. VXD should attend these meetings to examine opportunities for its own involvement in such a program.
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<table>
<thead>
<tr>
<th>Reptiles and Amphibians</th>
<th>Birds</th>
<th>Mammals</th>
</tr>
</thead>
<tbody>
<tr>
<td>American toad</td>
<td>Bufo americanus americanus</td>
<td>Didelphis virginiana</td>
</tr>
<tr>
<td>Green treefrog</td>
<td>Hyla cinerea cinerea</td>
<td>Blarina brevicauda</td>
</tr>
<tr>
<td>Leopard frog</td>
<td>Pseudemys scripta elegans</td>
<td>Dasypus novemcinctus</td>
</tr>
<tr>
<td>Red-eared turtle</td>
<td>Eumeces fasciatus</td>
<td>Sylvilagus floridanus</td>
</tr>
<tr>
<td>Five-lined skink</td>
<td>Natrix erythrogaster flavigaster</td>
<td>Sylvilagus aquaticus</td>
</tr>
<tr>
<td>Yellow-bellied water snake</td>
<td>Thamnophis sauritus sauritus</td>
<td>Tamias striatus</td>
</tr>
<tr>
<td>Eastern ribbon snake</td>
<td>Agkistrodon piscivorus leucostoma</td>
<td>Sciurus carolinensis</td>
</tr>
<tr>
<td>Western cottonmouth</td>
<td></td>
<td>Sciurus niger</td>
</tr>
<tr>
<td></td>
<td>Pied-billed grebe</td>
<td>Castor canadensis</td>
</tr>
<tr>
<td></td>
<td>Green heron</td>
<td>Oryzomys palustris</td>
</tr>
<tr>
<td></td>
<td>Turkey vulture</td>
<td>Peromyscus leucopus</td>
</tr>
<tr>
<td></td>
<td>Broad-winged hawk</td>
<td>Peromyscus gossypinus</td>
</tr>
<tr>
<td></td>
<td>Bobwhite</td>
<td>Ochrotomys nuttalli</td>
</tr>
<tr>
<td></td>
<td>American coot</td>
<td>Neotoma floridana</td>
</tr>
<tr>
<td></td>
<td>American woodcock</td>
<td>Ondatra zibethicus</td>
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<tr>
<td></td>
<td>Mourning dove</td>
<td>Mus musculus</td>
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<tr>
<td></td>
<td>Ruby-throated hummingbird</td>
<td>Vulpes vulpes</td>
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<td></td>
<td>Pileated woodpecker</td>
<td>Procyon lotor</td>
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<tr>
<td></td>
<td></td>
<td>Mustela vison</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mephitis mephitis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lynx rufus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Odocoileus virginianus</td>
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</tbody>
</table>
## Table E2

**Total Area and Forest Area of Counties in the Yazoo River Basin**
**By Major Physiographic Region**

<table>
<thead>
<tr>
<th>County</th>
<th>All Land</th>
<th>Commercial Forest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Thousand Acres</td>
<td>1967 Thousand Acres*</td>
</tr>
<tr>
<td>----------</td>
<td>------------</td>
<td>---------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Alluvial Plain</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bolivar</td>
<td>601.6</td>
<td>75.6</td>
</tr>
<tr>
<td>Coahoma</td>
<td>379.5</td>
<td>68.6</td>
</tr>
<tr>
<td>Holmes</td>
<td>493.4</td>
<td>214.7</td>
</tr>
<tr>
<td>Humphreys</td>
<td>270.1</td>
<td>68.0</td>
</tr>
<tr>
<td>Issaquena</td>
<td>285.5</td>
<td>128.0</td>
</tr>
<tr>
<td>Leflore</td>
<td>380.2</td>
<td>66.0</td>
</tr>
<tr>
<td>Quitman</td>
<td>283.7</td>
<td>42.7</td>
</tr>
<tr>
<td>Sharkey</td>
<td>279.0</td>
<td>95.4</td>
</tr>
<tr>
<td>Sunflower</td>
<td>444.2</td>
<td>36.9</td>
</tr>
<tr>
<td>Tallahatchie</td>
<td>412.8</td>
<td>127.5</td>
</tr>
<tr>
<td>Tunica</td>
<td>304.6</td>
<td>72.0</td>
</tr>
<tr>
<td>Warren</td>
<td>385.3</td>
<td>193.2</td>
</tr>
<tr>
<td>Washington</td>
<td>487.7</td>
<td>70.8</td>
</tr>
<tr>
<td>Yazoo</td>
<td>600.9</td>
<td>234.4</td>
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<tr>
<td><strong>Subtotal</strong></td>
<td>5,588.5</td>
<td>1,493.8</td>
</tr>
<tr>
<td><strong>Upland Region</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benton+</td>
<td>263.7</td>
<td>167.0</td>
</tr>
<tr>
<td>Calhoun</td>
<td>378.9</td>
<td>210.8</td>
</tr>
<tr>
<td>Carroll+</td>
<td>408.3</td>
<td>217.6</td>
</tr>
<tr>
<td>Chickasaw+</td>
<td>323.8</td>
<td>132.2</td>
</tr>
<tr>
<td>Desoto+</td>
<td>312.3</td>
<td>75.8</td>
</tr>
<tr>
<td>Grenada</td>
<td>286.1</td>
<td>161.4</td>
</tr>
<tr>
<td>Lafayette</td>
<td>434.5</td>
<td>259.2</td>
</tr>
<tr>
<td>Marshall+</td>
<td>454.4</td>
<td>212.2</td>
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<tr>
<td>Montgomery+</td>
<td>257.9</td>
<td>159.7</td>
</tr>
<tr>
<td>Panola</td>
<td>450.6</td>
<td>147.1</td>
</tr>
<tr>
<td>Pontotoc+</td>
<td>320.6</td>
<td>143.5</td>
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<tr>
<td>Tate</td>
<td>263.0</td>
<td>86.4</td>
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<tr>
<td>Tippah+</td>
<td>297.0</td>
<td>161.1</td>
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<tr>
<td>Union+</td>
<td>270.1</td>
<td>128.7</td>
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<tr>
<td>Webster</td>
<td>266.2</td>
<td>165.2</td>
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<tr>
<td>Yalobusha</td>
<td>322.6</td>
<td>184.5</td>
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<tr>
<td><strong>Subtotal</strong></td>
<td>5,310.0</td>
<td>2,612.6</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td>10,898.5</td>
<td>4,106.4</td>
</tr>
</tbody>
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* From Hedlund and Earles18
** From Van Hooser19
+ Total county figures although entire county not in basin
Table E3
Reduction in Carrying Capacities for North Louisiana Bottomlands Resulting from Clearing of Hardwoods and Associated Drainage of Wetlands (after Yancey21)

<table>
<thead>
<tr>
<th>Carrying Capacity</th>
<th>Deer</th>
<th>Squirrel</th>
<th>Swamp Rabbit</th>
<th>Turkey</th>
<th>Wood Ducks*</th>
<th>Migrant Waterfowl*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average in north Louisiana bottomland hardwood under standard selective logging practices</td>
<td>1/20 acres</td>
<td>1.3/acre</td>
<td>1/2 acres</td>
<td>1/75 acres</td>
<td>1/100 acres</td>
<td>1/10 acres</td>
</tr>
<tr>
<td>Total if all bottomlands were still in hardwoods (5,627,494 acres)</td>
<td>281,375</td>
<td>7,315,742</td>
<td>2,813,747</td>
<td>75,033</td>
<td>56,274</td>
<td>562,749</td>
</tr>
<tr>
<td>Total as of 1961 (3,300,158 acres of hardwood remaining)</td>
<td>165,008</td>
<td>4,290,205</td>
<td>1,650,079</td>
<td>44,002</td>
<td>33,000</td>
<td>330,015</td>
</tr>
<tr>
<td>Total as of 1968 (2,521,511 acres of hardwood remaining)</td>
<td>126,076</td>
<td>3,277,964</td>
<td>1,260,756</td>
<td>33,620</td>
<td>25,215</td>
<td>252,000</td>
</tr>
<tr>
<td>Average annual decline based on 1961-68 land-clearing rates (11,235 acres per year)</td>
<td>5,562</td>
<td>144,605</td>
<td>55,618</td>
<td>1,483</td>
<td>1,112</td>
<td>11,123</td>
</tr>
<tr>
<td>Total projected for the year 1985 (630,516 acres of hardwoods remaining)</td>
<td>31,526</td>
<td>819,670</td>
<td>315,208</td>
<td>8,406</td>
<td>6,305</td>
<td>63,051</td>
</tr>
</tbody>
</table>

* Declines are associated with drainage of wetlands such as cypress brakes and channelization of streams.
Table E4
Rare and Endangered Fauna in the Yazoo River Basin
(Compiled from MGFC22)

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Range in Mississippi</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Amphibians</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eastern tiger salamander</td>
<td>Ambystoma tigrinum tigrinum</td>
<td>Probably throughout state</td>
<td>Rare</td>
</tr>
<tr>
<td>Mole Salamander</td>
<td>Ambystoma talpoideum</td>
<td>Neotenic form scattered throughout state</td>
<td>Rare</td>
</tr>
<tr>
<td>Four-toed Salamander</td>
<td>Hemidactylium scutatum</td>
<td>Possibly statewide but localized</td>
<td>Rare</td>
</tr>
<tr>
<td><strong>Reptiles</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alligator snapping turtle</td>
<td>Macrolemys temmincki</td>
<td>Statewide except northeastern portion; most abundant in southern part of state</td>
<td>Rare</td>
</tr>
<tr>
<td>American alligator</td>
<td>Alligator mississippiensis</td>
<td>Delta Region, and southern two-thirds of state</td>
<td>Endangered</td>
</tr>
<tr>
<td>Scarlet king snake</td>
<td>Lampropeltis doliata doliata</td>
<td>Statewide</td>
<td>Rare</td>
</tr>
<tr>
<td>Scarlet snake</td>
<td>Cemophora coccinea</td>
<td>Statewide</td>
<td>Rare</td>
</tr>
<tr>
<td>Eastern coral snake</td>
<td>Micrurus fulvius fulvius</td>
<td>Southern three-fourths of state</td>
<td>Rare</td>
</tr>
<tr>
<td><strong>Birds</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Southern bald eagle</td>
<td>Haliaeetus leucocephalus</td>
<td>Winter visitor throughout state, occasionally breeds</td>
<td>Endangered</td>
</tr>
<tr>
<td>Peregrine falcon</td>
<td>Falco peregrinus</td>
<td>Occasional migrant throughout state</td>
<td>Endangered</td>
</tr>
</tbody>
</table>

(Continued)
<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Range in Mississippi</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Birds (Continued)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ivory-billed woodpecker</td>
<td>Campephilus principalis</td>
<td>Unknown</td>
<td>Endangered</td>
</tr>
<tr>
<td>Bachman's warbler</td>
<td>Vermivora bachmanii</td>
<td>Unknown</td>
<td>Endangered</td>
</tr>
<tr>
<td>Golden eagle</td>
<td>Aquila chrysaetos</td>
<td>Rare winter visitor throughout the state</td>
<td>Rare</td>
</tr>
<tr>
<td>Hoary bat</td>
<td>Lasiurus cinereus</td>
<td>May occur as a transient throughout state</td>
<td>Rare</td>
</tr>
<tr>
<td>Eastern big-eared bat</td>
<td>Plecotus rafinesquii</td>
<td>Statewide</td>
<td>Rare</td>
</tr>
<tr>
<td>Southeastern shrew</td>
<td>Sorex longirostris</td>
<td>Statewide</td>
<td>Rare</td>
</tr>
<tr>
<td>Red wolf</td>
<td>Canis rufus</td>
<td>May occur in western and northern part of state</td>
<td>Peripheral-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Endangered</td>
</tr>
<tr>
<td>Cougar</td>
<td>Felis concolor</td>
<td>May occur in any part of state</td>
<td>Endangered</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX E': ALTERNATE METHODOLOGY FOR WILDLIFE HABITAT INVENTORY

1. The methodology recommended in the main text of Appendix E contains the suggested types of and specifications for data to be collected and mapped for an overall basin inventory. This appendix describes a much more detailed inventory of the type that might be required for evaluating the wildlife habitats of specific sites, particularly for identifying endangered plant species.

Method of Sampling

2. For many years plant communities in the United States have been sampled with the use of quadrats. A quadrat is generally referred to as a square sample unit that in turn can be called a plot. This is a possible method for the Yazoo Basin study because of its adaptability to various kinds of vegetation, thus allowing the essential uniformity of techniques.

3. Obviously, plot size must be selected prior to analysis and generally depends on the size of plants to be studied. Plots usually range from 0.1 m\(^2\) to 100 m\(^2\). Quadrats of 100 m\(^2\) (10 m square) are commonly used for trees; 16 m\(^2\) (4 m square) for shrubs; 1 m\(^2\) (1 m square) for herbs, and one-fourth m\(^2\) (50 cm square) for mosses or other small plants.\(^{120}\) These quadrats are often nested, with smaller ones positioned in corners of the larger one. In many instances, 5-m-square plots are used for all woody plants rather than the 10-m-square plots for trees and the 4-m-square plots for shrubs and woody vines.

4. Fortunately, plot size has little influence on density and dominance data.\(^{121}\) Different sized plots can be used, therefore, and still be directly comparable. On the other hand, size of plot does have

* Superscript numbers refer to similarly numbered item in the Reference list following the main text of Appendix E.
an influence on frequency, constancy,* and any index of sociability that depends in part on frequency. Some discretion must be employed, therefore, to ensure exact duplication of plot technique. An important element in the Yazoo Basin study would be for various workers to use the same size plots in regard to the types of plants being studied.

5. Quadrats, in turn, can be positioned in belt transects (segmented-belt transects). The use of belt transects is recommended for the Yazoo Basin study because they save time and because of the overall superiority of elongated plots (transects).¹²¹,¹²² Their advantage is a result of the natural tendency of species to group or cluster. Segmented-belt transects have a greater chance of intercepting several clusters without falling entirely within one or missing all as might be the case with random sampling. The systematic placement of plots, whether contiguous or at predetermined distances within the belt transect, is statistically sound. Daubenmire¹²¹ stated that systematic and random sampling methods are equally objective.

6. Of sequential concern is the location of these segmented-belt transects within the community. Because systematic sampling saves time and can provide factual statistical data, the initial transect can be selected as randomly as possible while in the field and additional transects can be spaced at predetermined intervals throughout the community.

7. It should be mentioned in regard to methods of analysis that herbaceous species need to be analyzed at least monthly, beginning in March and ending in October. Trees, shrubs, and woody vines need only be analyzed once in each community because composition remains relatively constant through the growing season.

---

* Percentage of occurrence of a species in samples of a uniform size scattered over the geographic range of an association. Like frequency, it is a measure of ubiquity, but ubiquity among a series of stands representing one association, rather than among plots within a single stand.
8. Plot data can be analyzed in many ways to gain a better understanding of vegetation dynamics within a community. Frequency and density values should be obtained for herbaceous species and frequency, density, and dominance values for woody species.

9. It might be appropriate, at this point, to present an example concerning data acquisition and analysis. Say that a certain fairly homogeneous community is selected for analysis and the position of belt transects determined. Within each transect, various size plots are positioned: 50 cm square for mosses, 1 m square for herbaceous plants, 4 m square for shrubs and woody vines and 10 m square for trees. Mosses and herbaceous plants observed in their respective plots are identified and counted so that the number of individuals of each species is recorded. Woody plant data are recorded that include measurement of diameter at breast height (dbh), which is about 4-1/2 ft above ground, in addition to a count of the individuals present of each species. Also, if time allows, trees, shrubs, and woody vines with dbh less than one-half cm may be recorded. Oftentimes, however, it is very burdensome to count and identify these smaller plants including seedlings. If seedling, small shrub, and woody vine data are deemed essential, smaller plots could be considered for the acquisition of this information.

Frequency, density, and dominance values

10. The data procured for the various kinds of plants present can be used to determine the number of plots in which a species occurs, the number of individuals of each species, and, where appropriate, the dbh of each species. These data, in turn, can provide frequency, density, and dominance values for each species recorded.

11. Frequency, density, and dominance data can give information concerning the distribution, number, and dominance of species in the community. For herbaceous species (including mosses), frequency and density data should be obtained. Cover data could be acquired if time allows. Frequency and density data may be combined to present an importance value for each species; the importance value is equal to the
of relative frequency and relative density of a species. Frequency, density, and dominance data should be taken for woody species. These data can also be used to provide an importance value for each species. Importance value in this instance is equal to the sum of relative frequency, relative density, and relative dominance.

12. **Frequency data.** Frequency indicates the percentage of sample plots in which a given species occurs. It is, therefore, a measurement of the distribution of a species in the study area based upon its presence or absence in the plots. Size and numbers of plants are irrelevant. The frequency \( v \) in percentage is calculated from the following equation:

\[
v = \frac{\text{Number of plots in which the species occurred}}{\text{Number of plots taken}} \times 100 \quad (E'1)
\]

Data presented in Table E'1 were based on 50 plots and were used to formulate Table E'2. For example, *Heterotheca latifolia* was present in 43 of 50 plots, giving this species a frequency of 86 percent.

13. **Relative frequency** \( v_r \), a frequency value for a species relative to the other species sampled, can be calculated using the following equation:

\[
v_r = \frac{\text{Number of plots in which the species occurred}}{\text{Number of plots in which all species occurred}} \times 100 \quad (E'2)
\]

For example, using data from Table E'1, relative frequency for *Heterotheca latifolia* is determined by dividing the number of plots in which this species occurred (43) by the total number of plots in which all species occurred (226), giving a relative frequency value of 19.0 percent (Table E'2).

14. **Density data.** In addition to frequency values, the number of individuals of a species per unit area should be determined. This is referred to as density, which deals with numbers of individuals with the inference of distribution or size. It can be calculated from the following equation:

\[
E'4
\]
Density per plot = \( \frac{\text{Number of individuals of the species}}{\text{Number of plots taken}} \) (E'3)

Using data in Table E'1, a density of 2.28 plants per plot (Table E'2) is determined for Heterotheca latifolia by dividing the number of plants of this species (114) by 50 (the number of plots taken).

15. A relative density value for Heterotheca latifolia may be obtained using the following equation:

\[
\text{Relative Density} = \frac{\text{Number of individuals of the species}}{\text{Number of individuals of all species}} \]

(E'4)

The number of plants of this species (114) is divided by the total number of plants of all species (698) from Table E'1; the relative density for the species is 16.3 percent (Table E'2).

16. Dominance data. Dominance data, in addition to frequency and density data, should also be acquired whenever possible. Dominance data involve size rather than distribution or numbers. It may be expressed in relation to space or relative to other species. For this example, dominance will be used in regard to woody plants on a relative basis and will be calculated from dbh measurements. Although dbh values are not as precise as coverage data, dbh is more widely used than coverage because the measurements are more easily obtained. Diameter values can be converted to basal area, and relative dominance can be calculated using the following equation:

\[
\text{Relative Dominance} = \frac{\text{Total basal area of the species}}{\text{Total basal area of all species}} \times 100 \]

(E'5)

Using data presented for woody species in Table E'1, relative dominance is determined for Carpinus caroliniana by dividing its basal area (11,000) by the total basal area for all species (78,300) giving a value of 14.05 percent (Table E'3).

17. To gain a better understanding of the kinds of communities in the Yazoo Basin, it would be advantageous to determine the degree of
resemblance of the various communities analyzed. This may be accomplished for two communities through the following equation:

\[ c = \frac{2W}{a + b} \]  

(E'6)

where

- \( c \) = coefficient of similarity
- \( W \) = \( a \) or \( b \), whichever is the lesser value
- \( a, b \) = respective sums of the importance values for those species common in both communities

The degree of resemblance, therefore, is a result of species in common and their importance values.

Community ordination

18. Differences or similarities in community composition within the basin can be presented through a community ordination technique. This approach involves the positioning of communities in a two-axis graph. The program is based upon coefficients of similarity and can be accomplished following procedures outlined by Cox\(^{123}\) or Hall\(^{124}\). The program is quite lengthy and therefore should be computerized. The position of communities in the graph may also be correlated with environmental gradients.

Species interrelations and plant succession

19. It should be mentioned that knowledge gained from these analyses could be used to classify, map, and describe the vegetation of the basin. However, it is also of importance to obtain information concerning vegetation dynamics, e.g., interrelationships among species; plant succession (the natural replacement of one community by another); etc. It would be beneficial to include these data whenever possible, as they add another element of understanding.

Computer programs

20. Based upon the equations presented in this appendix (E'), computer programs can be prepared as an aid to data presentation and analyses in determining community dominance as based on importance values and coefficients of similarity between communities. A community
ordination computer program may be produced following the series of steps (equations) outlined by various authors such as Cox or could be purchased (e.g. for A. V. Hall, The Boluslterharium, University of Cape Town, Republic of South Africa).

Estimated Time Schedule

21. Herbaceous and woody vegetation analyses would require a minimum of two growing seasons (March to October). To allow for reconnaissance, establishment of plots, and data analyses, work should begin sometime in the fall and end sometime in the spring (e.g., begin 1 September 1976 and end 28 February 1978). The vegetation could be analyzed during the summers of 1977 and 1978.
Table E'1
Composition of a Hypothetical Plant Community

<table>
<thead>
<tr>
<th>Species</th>
<th>No. of plots</th>
<th>No. of plants</th>
<th>Basal Area cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Herbaceous Species</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heterotheca latifolia</td>
<td>43</td>
<td>114</td>
<td>--</td>
</tr>
<tr>
<td>Lactuca ludoviciana</td>
<td>38</td>
<td>103</td>
<td>--</td>
</tr>
<tr>
<td>Oenothera laciniata</td>
<td>33</td>
<td>95</td>
<td>--</td>
</tr>
<tr>
<td>Oxalis dillenii</td>
<td>19</td>
<td>97</td>
<td>--</td>
</tr>
<tr>
<td>Plantago virginica</td>
<td>22</td>
<td>74</td>
<td>--</td>
</tr>
<tr>
<td>Rumex hastatulus</td>
<td>15</td>
<td>81</td>
<td>--</td>
</tr>
<tr>
<td>Paspalum setaceum</td>
<td>18</td>
<td>62</td>
<td>--</td>
</tr>
<tr>
<td>Panicum oligosanthes</td>
<td>19</td>
<td>44</td>
<td>--</td>
</tr>
<tr>
<td>Vulpia octoflora</td>
<td>11</td>
<td>17</td>
<td>--</td>
</tr>
<tr>
<td>Bromus commutatus</td>
<td>8</td>
<td>11</td>
<td>--</td>
</tr>
<tr>
<td>TOTAL</td>
<td>226</td>
<td>698</td>
<td></td>
</tr>
<tr>
<td><strong>Woody Species</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carpinus caroliniana</td>
<td>28</td>
<td>65</td>
<td>11,000</td>
</tr>
<tr>
<td>Planera aquatica</td>
<td>5</td>
<td>9</td>
<td>600</td>
</tr>
<tr>
<td>Acer rubrum</td>
<td>16</td>
<td>20</td>
<td>12,000</td>
</tr>
<tr>
<td>Quercus lyrata</td>
<td>33</td>
<td>52</td>
<td>25,000</td>
</tr>
<tr>
<td>Ulmus americana</td>
<td>2</td>
<td>2</td>
<td>700</td>
</tr>
<tr>
<td>Crataegus opaca</td>
<td>8</td>
<td>15</td>
<td>300</td>
</tr>
<tr>
<td>Quercus nigra</td>
<td>7</td>
<td>9</td>
<td>4,500</td>
</tr>
<tr>
<td>Fraxinus pennsylvanica</td>
<td>21</td>
<td>34</td>
<td>17,000</td>
</tr>
<tr>
<td>Liquidambar styraciflua</td>
<td>10</td>
<td>14</td>
<td>6,000</td>
</tr>
<tr>
<td>Diospyros virginiana</td>
<td>5</td>
<td>6</td>
<td>1,200</td>
</tr>
<tr>
<td>TOTAL</td>
<td>135</td>
<td>226</td>
<td>78,300</td>
</tr>
</tbody>
</table>

*A total of 50 plots were sampled.*
Table E'2
Distribution and Importance Values of Herbaceous Species in a Hypothetical Plant Community

<table>
<thead>
<tr>
<th>Species</th>
<th>Frequency Percent</th>
<th>Relative Frequency Percent</th>
<th>Density No./plot</th>
<th>Relative Density Percent</th>
<th>Importance Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heterotheca latifolia</td>
<td>86</td>
<td>19.0</td>
<td>2.28</td>
<td>16.3</td>
<td>35.3</td>
</tr>
<tr>
<td>Lactuca ludoviciana</td>
<td>76</td>
<td>16.8</td>
<td>2.06</td>
<td>14.8</td>
<td>31.6</td>
</tr>
<tr>
<td>Oenothera laciniata</td>
<td>66</td>
<td>14.6</td>
<td>1.90</td>
<td>13.6</td>
<td>28.2</td>
</tr>
<tr>
<td>Oxalis dillenii</td>
<td>38</td>
<td>8.4</td>
<td>1.94</td>
<td>13.9</td>
<td>22.3</td>
</tr>
<tr>
<td>Plantago virginica</td>
<td>44</td>
<td>9.7</td>
<td>1.48</td>
<td>10.6</td>
<td>20.3</td>
</tr>
<tr>
<td>Rumex hastatus</td>
<td>30</td>
<td>6.6</td>
<td>1.62</td>
<td>11.6</td>
<td>18.2</td>
</tr>
<tr>
<td>Paspalum setaceum</td>
<td>36</td>
<td>8.0</td>
<td>1.24</td>
<td>8.9</td>
<td>16.9</td>
</tr>
<tr>
<td>Panicum oligosanthes</td>
<td>38</td>
<td>8.4</td>
<td>0.88</td>
<td>6.3</td>
<td>14.7</td>
</tr>
<tr>
<td>Vulpia octoflora</td>
<td>22</td>
<td>4.9</td>
<td>0.34</td>
<td>2.4</td>
<td>7.3</td>
</tr>
<tr>
<td>Bromus commutatus</td>
<td>16</td>
<td>3.5</td>
<td>0.22</td>
<td>1.6</td>
<td>5.1</td>
</tr>
</tbody>
</table>

TOTAL                                                   99.9 | 13.96       | 100.0        | 199.9                  |

* Importance value is the sum of relative frequency and relative density.
Table E'3  
Distribution and Importance Values of Woody Species in a Hypothetical Plant Community

<table>
<thead>
<tr>
<th>Species</th>
<th>Frequency Percent</th>
<th>Relative Frequency Percent</th>
<th>Density No./plot</th>
<th>Relative Dominance Percent</th>
<th>Importance Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Quercus lyrata</em></td>
<td>68.75</td>
<td>24.44</td>
<td>1.08</td>
<td>23.01</td>
<td>31.93</td>
</tr>
<tr>
<td><em>Carpinus caroliniana</em></td>
<td>58.33</td>
<td>20.74</td>
<td>1.35</td>
<td>28.76</td>
<td>14.05</td>
</tr>
<tr>
<td><em>Fraxinus pennsylvanica</em></td>
<td>43.75</td>
<td>15.56</td>
<td>0.71</td>
<td>15.04</td>
<td>21.71</td>
</tr>
<tr>
<td><em>Acer rubrum</em></td>
<td>33.33</td>
<td>11.85</td>
<td>0.42</td>
<td>8.85</td>
<td>15.33</td>
</tr>
<tr>
<td><em>Liquidambar styraciflua</em></td>
<td>20.83</td>
<td>7.41</td>
<td>0.29</td>
<td>6.20</td>
<td>7.66</td>
</tr>
<tr>
<td><em>Quercus nigra</em></td>
<td>14.58</td>
<td>5.18</td>
<td>0.19</td>
<td>3.98</td>
<td>5.75</td>
</tr>
<tr>
<td><em>Crataegus opaca</em></td>
<td>16.67</td>
<td>5.93</td>
<td>0.31</td>
<td>6.64</td>
<td>0.38</td>
</tr>
<tr>
<td><em>Planera aquatica</em></td>
<td>10.42</td>
<td>3.70</td>
<td>0.19</td>
<td>3.98</td>
<td>0.77</td>
</tr>
<tr>
<td><em>Diospyros virginiana</em></td>
<td>10.42</td>
<td>3.70</td>
<td>0.12</td>
<td>2.66</td>
<td>1.53</td>
</tr>
<tr>
<td><em>Ulmus americana</em></td>
<td>4.17</td>
<td>1.48</td>
<td>0.04</td>
<td>0.88</td>
<td>0.89</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>99.99</strong></td>
<td><strong>4.70</strong></td>
<td><strong>100.00</strong></td>
<td><strong>100.00</strong></td>
<td><strong>299.99</strong></td>
</tr>
</tbody>
</table>

* Importance value is the sum of relative frequency, relative density, and relative dominance.
APPENDIX F:  SOCIOCULTURAL RESOURCES OF THE YAZOO BASIN
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TABLE F1
U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

<table>
<thead>
<tr>
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<th>To Obtain</th>
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</thead>
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PART I: INTRODUCTION

1. An understanding of the complex human resources of the Yazoo Basin is crucial to the planning process--for impact analysis as well as implementation of development plans. Frequently the areas that are most decisive in determining whether or not technical or scientific ventures are accomplished are the social, economic, and political characteristics of an area. In this appendix, attention will be directed toward concepts and principles in these areas as well as the details of data availability and acquisition. Basic concepts of planning and its implementation will be presented with particular reference to the situation in the Yazoo Basin and to the role of the Corps of Engineers therein.

2. The magnitude and complexity of the Yazoo Basin and the myriads of various institutional jurisdictions necessitate careful consideration of the subdivision of the basin into subbasin planning units that have a maximum of commonality and a minimum of conflict and confusion. Closely related to this subdivision of the basin, as well as to impact analysis, is the need for a more definitive assessment of the social and cultural patterns, values, and attitudes, which are of course interrelated with the economy and levels of living, educational and health service opportunities, and recreational and leisure alternatives.

3. A clarification of the definition and scope of the term "sociocultural" is required at this point. "Sociocultural" will be used throughout this appendix to denote all resources of the Yazoo Basin pertaining to the human population. This definition encompasses the characteristics usually specified as social, political, and economic, as well as cultural. When and wherever the term "sociocultural" appears in this appendix, it should be noted that these several facets are always included. This generally inclusive usage is theoretically acceptable, as the definition of "culture" actually encompasses all of these characteristics of a population. The term "sociocultural" may be equated, then, with the broad idea of the human resources of the Yazoo Basin.
4. A prerequisite to an understanding of the existing and potential human resources of the Yazoo Basin is an understanding of its history. A delineation of this background will allow for an appreciation of the human patterns and processes, specifically, the heritage of the area—social, political, economic, and cultural—and its evolution into the current conditions. A sensitivity to the established customs and institutions, power structures, communication channels, and firmly held values may preclude conflicts in a program of planned change. Violations of or intrusions upon this heritage, whether or not they are recognized as such by the parties involved, will undisputably result in major if not insurmountable problems for the planners.

5. The background and heritage of the people of the Yazoo Basin are inextricably intertwined with that of the region, the State, and the Nation. If the planning effort is to be truly comprehensive and objective, these larger considerations must be taken into account. It is necessary to examine the basin's attributes, problems, and potentials in the perspective of national conditions and policies regarding resource use, development, and consumption. The regional interrelationships as well as the metropolitan and urban influences have and will continue to affect significantly the development of the human resources of the Yazoo Basin and the implementation of any programs of planned change therein.

6. Understanding the current complex interrelationships that influence the human resources of the Yazoo Basin also involves the boundaries of the basin itself and the many subarea delineations within it. The Yazoo Basin is too large and too complex and has too many varying conditions within its boundaries to be treated as a whole in the planning process. This is especially true in view of the stated objectives of striving for coordination with other agencies and organizations and for constructive input and participation by the public. A presentation of many of the pertinent subbasin delineations may serve to illustrate the necessity for some standardization as well as allow for the creation of a basis for data comparison and compilation from the several agencies and organizations with programs in the Yazoo Basin. Such a delineation
of subbasin areas and an awareness of these patterns, mandates, and jurisdictions are vital if the planning efforts are to take advantage of existing institutions and minimize duplication and confusion in the human factor of the basin. Data in this section are also integral to the analysis of potential impacts on the political, social, and economic facets of the human resources of the Yazoo Basin.

7. In order to provide specifically for impact analysis on human resources as well as to enhance the implementation of the planning process, other specific types of data on the social, political, and economic sectors of the Yazoo Basin are required. It is imperative that the planners develop and maintain an understanding of and sensitivity to the varied and interrelated elements of the human resources of the area, as well as the relationships between this factor and the other factors involved in the analysis of effects on environmental quality, national economic development, regional development, and social well-being. The basic elements of the sociocultural environment include historical, anthropological, demographic, attitudinal, political, and economic data. The integration of these data and their collection with the other types of data in this report should ultimately result in the enhancement of the viability, meaningfulness, and usefulness of the entire planning process.
8. The development of the human resources of the Yazoo Basin is the story of people whose lives were influenced and fashioned by the Yazoo and those who today are attempting to better their way of life by refashioning the Yazoo itself. The development and heritage of the social, cultural, and economic resources of the basin have left an indelible mark on the course of progress in the area.

9. The first agriculturists in the Yazoo Basin were the Choctaw Indians. The Choctaw and Chickasaw tribes had settled in the area, but the Chickasaws relied heavily on hunting as a means of providing food. The Choctaws, on the other hand, predominated in Mississippi because of their adaptation to the ways of economic success. They were successful farmers when most of the other nomadic tribes hardly knew how to raise the staple crop of corn.

10. White men did not begin to move into the Yazoo Basin until after Mississippi had become a state in 1817. At the time, the bluffs and rolling hills of the Upland Region were the great prizes to be wrested from the Indians. It was not until after the Civil War, however, that the Alluvial Plain ceased to be known as the wilderness. Any man who was brave enough to explore the area found it a morass of forest, swamp, and cypress brake, seemingly all of it under water half the time. Even though there had been sparse pioneer settlements of both planters and squatters before the land was ceded by the Indians, the Alluvial Plain was still a frontier for years after the Civil War.

11. Any account of the social, cultural, and economic resources of the Yazoo Basin has to include the role of cotton, the staple that has dominated the history of man on the Yazoo. Before the Civil War, the bluffs and rolling hills of the Upland Region were the frontier of cotton during the famous flush times of the southwest. The planters of the region where cotton was so vigorously ruling were chief among the secessionists in 1860, eager to preserve the system that had opened up new land for them and that annually produced a heavy harvest from the fertile land.
12. If the Civil War had been postponed for a few years, the enthusiasm for the plantation system and for slavery might have been considerably dampened. The topsoil was thin throughout the Upland Region, and it began to wash away just as soon as farming began to flourish after the war. The cash-crop economy was a major contributing factor to the rapid erosion of the land, but the decline in fertility was inevitable from the start. Only the Alluvial Plain, the major portion of the Yazoo Basin, was rich enough to sustain the new cotton economy for a long period of time.

13. After the Civil War, it became the time for a new type of pioneer, one who could get the most results from the black laborers who were then freemen. Slave labor was replaced by share-cropping; the tenant farmer was extended credit to be repaid along with a share of the harvest. It was through this improvised credit system that the last stronghold of the feudal plantation was maintained, which did not change materially until it felt the impact of the economic revolution in the 1940's.

14. It is in this evolutionary pattern that the interrelationships between all of the resources of the Yazoo Basin become evident. The political, economic, and social spheres influenced and in turn were affected by the geology and physiography; the physical, chemical, and hydrological characteristics; and the aquatic and terrestrial resources of the Yazoo Basin. These influences were both positive and negative. The improvised credit system caused farm practices that turned rich acres into gullies and washed countless tons of irrereplaceable topsoil down into the Yazoo. There were other contributing factors, such as the lack of markets, absence of storage, and undeveloped transportation facilities, that could be traced back to the overall poverty of the region. The share-crop system, established out of expediency after the end of the Civil War, gradually faded due to its own shortcomings. People began to move down to the Alluvial Plain and try their luck with the new hazards of the swamplands. For 75 years, as the swampland was gradually released, new farmland put into production, and new towns created, the Alluvial Plain absorbed the surplus population of the rest
of the basin, both black and white. Cotton continued supreme and the so-called Delta type of plantation economy set the social and economic pattern for half a million people until the revolution of the 1940's.

15. The agriculture and life in the Yazoo Basin is interrelated with the river. The rich earth of the Alluvial Plain itself is sediment from countless prehistoric floods. The history of the region has been built around the fight to restrain and control the floods that would ravage instead of enrich the settled land. Control of the Yazoo floods was left to chance and isolated local effort for nearly a century. Levee boards, organized by state law as governmental subdivisions with tax authority, were the first efforts to coordinate flood-control activities in the Alluvial Plain, but for a long period they had no major responsibility for any flood fight except that against the Mississippi River. The farmers had to organize themselves into local drainage districts, with full taxing authority, as the only means of coordinating localized flood-control problems. A few are still in operation today, but their programs have been coordinated with those of the Corps of Engineers and the Soil Conservation Service (SCS). The Federal Government has been involved since 1873, when the Mississippi River Commission was created. Watershed conservation programs, originated in 1936, are coordinated with the SCS and the U. S. Forest Service. There is some feeling that the loosely coordinated flood-control and soil conservation programs in operation in the Yazoo Basin are typical of what must succeed throughout rural America.

16. The mechanization of cotton farming minimized most of the undesirable features of the old plantation system that had controlled the Yazoo Basin after the Civil War. Only the richness of Alluvial Plain soil enabled the system to survive as long as it did. That richness has helped to smooth the transition into mechanized cotton farming in conjunction with a new system of diversified general agricultural production.¹

17. The overview of the history of the Yazoo Basin in terms of its population is necessary to gain a full appreciation of the people of the area today, in order to project what may be ahead in the future.
To approach the human resources of the Yazoo Basin sociologically or analytically, it is necessary to have at least an appreciation if not a full understanding, of the forces and processes that brought them to where they are. In the area under consideration specifically, a sensitivity to the "ruralness" of the population and the variety of influences involved is mandatory.
PART III: REGIONAL AND OTHER RELATIONSHIPS RELEVANT TO PLANNING FOR THE YAZOO BASIN

18. The objective of this section, which discusses sociocultural data availability and needs for the comprehensive planning for water and related land resources of the Yazoo Basin of Mississippi, is to stimulate inquiry into broader interregional and national concerns than are the subject of most of this appendix. This is based upon the premise that there are larger considerations that must be taken into account, in addition to the physical, biological, economic, social, and cultural characteristics within the basin, if the planning effort by the U. S. Army Engineer District, Vicksburg (VXD), is to be truly comprehensive and objective in its response to the "Principles and Standards" promulgated by the Water Resources Council. It is necessary to view the basin's attributes, problems, and potentials in the perspective of national conditions and policies regarding resource use, development, and consumption.

National and State Considerations

19. Planning for water and related land resources of the Yazoo Basin of Mississippi cannot be performed in a provincial or parochial vacuum, in the insulated and isolated ivory tower of a research or planning institution or of an operational agency. To do so would delimit the possibilities and potentials inherent in the planning process and in the development of the resources of the basin. The planning perspective and parameters must be as broad as those of the Nation, yet as narrow as those of the inhabitants of the basin.

20. The Yazoo Basin in the map of the contiguous United States, Figure F1, is viewed at quite a different perspective than in the map of the hydrologic limits of the basin in Figure F2. To the 705,400 residents of the Yazoo Basin at the beginning of 1975 and to those involved in the preparation of this report and the implementation of its recommendations, the basin and its problems and needs loom large.
Figure F1. The Yazoo Basin of Mississippi in relation to the contiguous United States
Figure F2. Hydrologic boundaries of the Yazoo Basin of Mississippi
Although all the residents of the basin make up only 0.3319 percent of the total population of the United States and only 0.3338 percent of the population of the 48 contiguous states shown in the map in Figure F1, this one-third percent is very significant to those who comprise it. The ratio of relative significance of the land area of the Yazoo Basin to that of the United States is somewhat greater, the basin making up 0.45 percent of the land area of the contiguous states, and 0.37 percent of the total of the 50 states.

21. Narrowing the perspective to the relationships between the Yazoo Basin and the State of Mississippi causes the former to loom much larger. The map in Figure F3 shows that this basin comprises the northwestern quarter of the State. The 13,214 square miles* of land area of the basin is 27.9 percent of the total land area of the State (basin area derived by SCS's measurement of the hydrologic basin as reported in the "Yazoo-Mississippi River Basin Study"\(^4\)). As of the first of January 1975, the population of the 30 counties of the basin (using county-line boundaries rather than hydrologic boundaries) was 705,400 or 30.4 percent of the total population of Mississippi.\(^3\)

22. Consideration of several issues is in order:

a. The importance of the Yazoo Basin and its people, institutions, and enterprises in the total national perspective.

b. The significance to the rest of the Nation of alleviation or an amelioration of economic and social problems related to flooding, poor drainage, water quality, and so-called environmental quality in general.

c. The expressions of or criteria for national policy relative to allocating funds to the Yazoo Basin rather than to other basins or to other subjects of national concern.

d. The past and current comprehensive planning for water and related land resources.

This section is intended to raise issues pertinent to the planning process for the Yazoo Basin. The next several pages will, hopefully, provide some guidance in this area.

\* A table of factors for converting U. S. customary units of measurement to metric (SI) units is found on page F3.
Figure F3. State and regional relationships of the Yazoo Basin
23. The Yazoo Basin occupies only 1.1 percent of the total area of the Mississippi River's vast 1,245,000-square-mile drainage area; the relative sizes are depicted in Figure F4. However, more important than is suggested by gross areal comparisons is the significance of the relationship of the basin to the Mississippi River system.

24. The magnitude of the amount of water funneled into the main stem of the Mississippi by the time it forms the western boundary of the Yazoo Basin is overwhelming. The greatest flow of record on the Mississippi was at Vicksburg, below the confluence of the Yazoo, 2,080,000 cfs in February 1937. It is estimated that when the flood of 1927 was at its peak, its flow was 2,278,000 cfs at Vicksburg, although it was not possible to measure this due to the conditions at the time. The average annual flow into the Gulf of Mexico is 328 million acre-ft, a rate of 453,000 cfs. The daily average flow of over 300 billion gallons of water in the lower reaches is more water than is used in the entire country daily.

25. The chart of projected design floods in Figure F5 indicates the Yazoo River's contribution to the Mississippi to be small compared with larger systems such as the Arkansas or Tennessee. However, the design flow from the Yazoo, 25,000 cfs, is 9.2 percent of the 2,710,000 cfs in the Mississippi at Vicksburg. Improvements in water and related land management in the Yazoo Basin will make a significant difference in the quality, quantity, and timing of their discharges into the Mississippi. Backwater flooding by the Mississippi into the Yazoo Basin's Alluvial Plain is further evidence of the inextricable inter-relationship between the two hydrologic systems.

26. The navigational role of the main stem of the Mississippi as it parallels the western boundary of the Yazoo Basin is in sharp contrast to the destructive flooding of the river. The port communities of Greenville and Vicksburg, both in the Yazoo Basin, are directly linked to the main stem of a network of inland navigable waterways that form a system about 12,350 miles long. This figure does not include the
Figure F4. Relationship of the Yazoo Basin to the Mississippi River Drainage System (from the U. S. Army Engineer Division, Lower Mississippi Valley (LMVD))
Figure F5. Projected design floods (from LMVD7)
connecting 1,173 miles of the Gulf Intracoastal Waterway (GIWW) (see Figure F6). Combined tonnages at Greenville and Vicksburg, while constituting only 2.1 percent of the 1972 total tonnage of 11 major riverports from Minneapolis-St. Paul to New Orleans, registered an increase of 107.6 percent between 1962 and 1972, compared to a 76.0-percent increase for all 11 ports. The impact of inland waterway navigation upon the economy of the Yazoo Basin is apparent, but needs further documentation as to the overall, area-wide benefits. Inland waterway navigation has great relevance to the VXD comprehensive study plan, especially in view of the national energy crisis and the relative economy of waterborne shipments. This relevance in turn affects the authorized improvement of navigation on the Yazoo River from Vicksburg to Greenwood, which in turn will impact favorably upon the entire basin.

27. Another unique attribute of the Yazoo Basin is that about half the area is a part of the vast alluvial valley of the Lower Mississippi River (see Appendix B). Figure F7 depicts this broad regional inter-relationship. The lower valley is over 600 miles long by 30 to 125 miles wide, and it embraces about 35,000 square miles of the earth's surface. The 6,600 square miles within the Yazoo Delta is nearly one-fifth of the seven-state total. The alluvial valley is said to be among the most fertile and productive regions in the world with regard to plant growth, and the Alluvial Plain of the Yazoo Basin is said to be the most agriculturally productive region of the entire valley. One unique specialty crop in the Delta is its certified cotton seed production, processing, and distribution; it has been reported that although the Alluvial Plain grows slightly less than 10 percent of the American cotton crop, it breeds more than two-thirds of the seed for the Nation.

28. The capability of the Yazoo Alluvial Plain to produce premium long-staple cotton places it in a most favorable position in relation to other cotton-producing areas of the Nation and the world. Although surplus storm and flood waters are frequently a tragic nightmare to the farmers of the Alluvial Plain, the consistent availability of water during the growing season is a distinct advantage over other cotton-producing areas where Federal subsidy has encouraged the transport of
The Mississippi is the only river in North America ranking in the 10 largest of the world's rivers. Of these 10, the Mississippi is third in length, third in drainage area, and fifth in volume.

For comparative purposes, the length of rivers is calculated through the longest tributary; i.e., the total length of the Mississippi is considered to be 3,484 miles, since its longest tributary, the Missouri, is 2,315 miles long measured from its headwaters at Three Forks, Mont., where the Jefferson, Madison, and Gallatin Rivers unite.

The length of the Mississippi from its headwaters in Minnesota is as follows:

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<th>Reach</th>
<th>Length (miles)</th>
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<tbody>
<tr>
<td>Lake Itasca (headwaters) to Minneapolis, Minn.</td>
<td>513</td>
</tr>
<tr>
<td>Minneapolis, Minn., to Cairo, Ill. (Ohio River)</td>
<td>853</td>
</tr>
<tr>
<td>Cairo, Ill., to New Orleans, La. (Canal Street)</td>
<td>859</td>
</tr>
<tr>
<td>New Orleans, La., to Head of Passes, La.</td>
<td>95</td>
</tr>
<tr>
<td>Head of Passes (via Southwest Pass) to Gulf of Mexico, La.</td>
<td>20</td>
</tr>
<tr>
<td>Total Length</td>
<td>2,340</td>
</tr>
</tbody>
</table>

Figure F6. Mississippi River navigation system (from LMVD6)
Figure F7. Yazoo Basin in relation to the alluvial valley of the Lower Mississippi River (from LMVD5)
water to produce cotton that is in competition with that produced by the agriculture and social-cultural infrastructure of the Mississippi alluvial valley. The plan for water and related development of the Yazoo Basin must compare the cost of flood protection and drainage improvements in the Alluvial Plain with costs of reclamation and settlement of new agricultural enterprises and institutions in other parts of the Nation, and both must be tested against the accounts advocated by the Water Resources Council. Failure to perform such interregional comparisons would diminish the objectivity and usefulness of the Yazoo Basin plan.

29. The preceding brief discussion of the relationship between navigation, energy crises, and planning policies leads to more questions regarding their projection to the planning target year of 2030 and thus their effect upon the growth or decline of the economy of the Yazoo Basin. To date, very little substantive data have been found as to these types of projections or their impacts. The strategic position of the Yazoo Basin's Mississippi River frontage for both industrial and recreational navigation, as well as for electric power plant siting, is indicated on the accompanying map (Figure F8) showing the basin in relation to the eastern part of the Mississippi River Navigation System and connecting waters. The dots on the map are the locations of Standard Metropolitan Statistical Areas (SMSA's) and are included to suggest the need to research their growth patterns further as related to waterborne commerce. Such information might provide insight and guidance in projecting future industrial, recreational, and other developments in the Yazoo Basin plan.

Metropolitan and Urban Influences

30. A closer look at metropolitan area development that has more direct bearing upon economic and social characteristics of the Yazoo Basin is afforded by the map in Figure F9. The multi-county (in most cases) metropolitan areas are defined by the U. S. Census and Office of Management and Budget as SMSA's, to which have been added "potential"
Figure F8. Relationship of the Yazoo Basin to the eastern part of the Mississippi River System
Figure F9. Metropolitan county areas within 200 miles of the center of the Yazoo River Basin (metropolitan areas from Sales Management)
SMSA's by Sales Management. 3

31. The Memphis SMSA includes DeSoto County at the northern end of the Yazoo Basin, and the Jackson SMSA borders on or near the southern end of the basin. Within 200 miles of the center of the basin are 11 SMSA's with a combined 1975 population of 3,189,300 and an aggregated effective buying income of $13,196,000,000. Seventeen more SMSA's lie within the 200- to 300-mile zone from the center of the basin, with a combined population of 4,983,700 and an effective buying income of $20,258,000,000. The presence of these concentrated masses of people and purchasing power has many ramifications for the future of the Yazoo Basin. Most of them are located on navigable streams of the Lower Mississippi River System, a fact that almost ensures their continued growth and territorial expansion.

32. There have been few valid studies, for example, of origin-destination patterns, frequency of travel, activity preferences, and expenditures of tourists and other recreationists visiting the Yazoo Basin or the State of Mississippi. One such study, sponsored by the Land Use Center of Mississippi State University, dealt only with the state of origin of visitors to the four Corps reservoirs in the Yazoo Basin Upland Region; this revealed a nearly classical application of the distance-decay function based upon miles from the Tennessee state line. 9 This relationship is symbolized in Figure F10, which is a representation of the relative importance of the extra-basin SMSA's of Memphis and Jackson compared with the spheres of influence of the four largest cities within the basin and their county populations.

33. A cursory analysis of county-level demographic and economic data was made to consider their applicability and limitations for the ongoing study. Some county characteristics are mentioned here to emphasize the influence of metropolitan areas, as well as to demonstrate data utilization in impact analysis and projection. Comparisons were made among the 30 counties that lie wholly or partially in the Yazoo Basin with the basin totals and averages; these were compared with those of the entire State of Mississippi, the nine U. S. Census regions
AREAS OF CIRCLES REPRESENT SMSA OR BASIN COUNTY POPULATION, 1975.

PROPORTIONATE POPULATION-DISTANCE DECAY INTERSECTION POINT BETWEEN JACKSON AND MEMPHIS SMSA'S.

Figure F10. Metropolitan and urban influences (populations from Sales Management3)

F26
of the Nation, and the United States as a whole, as represented in Figure F11.

34. DeSoto County, Mississippi, was selected for this comparison because it is the only county in the otherwise very rural Yazoo Basin that is included within an SMSA. From a statistical point of view, the family income levels and distribution, as reflected by Sales Management's "effective buying power" or purchasing power, are much more nearly comparable to those of the urban-industrial regions of the upper Midwest and the mid-Atlantic regions than to those of the southern states and the average for the entire Yazoo Basin. Median household effective buying power is 62 percent higher than for the basin as a whole and 28 percent higher than for the State of Mississippi.

35. Warren County, Mississippi, was included in the tabulation as it was second only to DeSoto among the basin counties in per-household purchasing power. In both counties the influences upon social well-being, if income and purchasing power are an indicator thereof, result from extra-basin factors that are but slightly related to the natural resources within the basin. Memphis is a big and burgeoning regional trade, service, and cultural center due mainly to locational factors. Vicksburg, in Warren County, is the largest city in the Yazoo Basin and is the office and residential headquarters of three large governmental units of the Corps of Engineers and several smaller ones, as well as being a riverport town with an expanding port and industrial base and a port-of-entry for tourists entering Mississippi from the west. Such exogenous or outside factors have profound influence upon the basin and must be compared with the endogenous or internal conditions and forces.

Further Studies in Interregional Comparative Advantage

36. The foregoing presentation on regional relationships that affect the planning and projection for the Yazoo Basin pose some rather serious questions as to the validity of some of the planning approaches required by the Water Resources Council and the Office, Chief of Engineers. If the Yazoo Basin is to become one of the first river
Figure F11. Effective buying income comparison by regions and United States total (map from Bureau of the Census,10 incomes from Sales Management3)
basins in the Nation to apply the Water Resources Council "Principles and Standards" in its planning, a thorough understanding of the guidelines and aids is imperative. Such clarification and refinement in the process are legitimate parts of the process of planning.

37. For example, at a time when many agencies, organizations, and individuals, including the LMVD, are concerned about the possible export of surplus Mississippi River water to the high plains of the Texas Panhandle, should there not be a national policy enacted and enforced proclaiming a position on the pros and cons (including but not solely determined by benefits and costs) of continuing to create new economic opportunities in remote arid areas while carrying the social welfare costs of supporting the surplus and displaced population throughout the Old South? From the criteria of national and regional economic objectives, social well-being, and environmental quality, what are the overall comparative advantages of cotton production in the Yazoo Delta and of development of the arid and semi-arid Southwest? What are the interregional relative advantages in all accounts of the production of soybeans, rice, timber products, recreation, fish and wildlife, navigation and port-industrial development, power production, and new residential/recreational communities in the Yazoo Basin? What would be the impact of, say, a 2-percent per year increase over the rate of national increase in labor productivity through more generous and enlightened programs in education, vocational, and technical training, and health services in the Yazoo Basin?

38. A little bit of difference in planning assumptions can make big differences in the accuracy, acceptability, and effects of the plan. The Yazoo Basin and its interregional relationships are unique, as is every individual and community of individuals. Planning for water and related land resource development to the year 2030 must better define and understand this uniqueness before it succumbs to an impersonal constriction of its potentiality as imposed by vaguely conceived and articulated national objectives, principles, and standards.
PART IV: BASIN AND SUB-BASIN BOUNDARIES OF THE YAZOO BASIN

39. The interrelationships of influences, patterns, mandates, and jurisdictions within, as well as outside, the basin hinge in the main on the boundaries of the organizations and institutions involved. This is very much the concern of the human sector, most of the boundaries being influenced by economic, political, or social considerations. A meaningful framework for plan development and implementation should emerge from a study of these arrangements.

Basin Boundaries

40. The entire area or portions of 30 counties lie within the Yazoo Basin's hydrologic boundaries (Figure F12). Most reports and tabulations consider only the area delimited by this watershed when measuring basin characteristics. However, some reports have included characteristics from the entire area of the 30 counties, while others have referred only to the area within those counties that are totally within the watershed. There also seems to be no agreement as to whether or not the area to the west of the Mississippi River levees to the state line should be included in the Yazoo Basin. Although this area is not in the hydrologic basin of the Yazoo, the Mississippi River does back up into the basin during floods. Further, the social, cultural, and economic effects of port towns and riverfront areas suggest that the western boundary should be considered as the state line, which is generally the center of the Mississippi River, except where it has migrated.

41. It is recommended that all agencies and organizations adopt the same definitions as to the basin boundaries and areas so that there can be uniformity in data. This could be a minor but useful function of the basin planning program of the Corps and its coordination with other agencies.
Figure F12. Yazoo Basin boundary (approximate)
Subbasin Delineations of the Yazoo Basin

42. There are probably as many subdivisions of the basin as there are agencies, organizations, and people within the basin. In the half of the basin that is occupied by the Yazoo Alluvial Plain (see Appendix B), subdivision of the area into smaller, workable planning units is further complicated by the almost featureless plain that lacks topographic delineation between the major and tributary streams and their individual watersheds. In the Alluvial Plain, the streams have meandered and changed course so many times that any subwatershed delineation must be considered as being transitory except where man-made channels and other structures tend to fix them to a given location, and a major flood can change that.

43. Several of the subbasin delineations that are especially pertinent to the planning for water and related land resources will be presented in this section. The purpose is not to emphasize the areal jurisdictional problems but to illustrate the necessity for some standardization of subarea boundaries for the purpose of improved communication and coordination. It is currently virtually impossible to make comparisons of data among the several agencies and organizations with programs in the Yazoo Basin because of the different ways in which subbasin areas are delineated. As with a more uniformly used definition of the boundaries and areal extent of the entire basin, the delineation of subbasin boundaries might be an important contribution by the planning program of the Corps.

44. The Corps is and has been concerned about and responsible for certain aspects of water resource management in the entire Yazoo by various congressional authorizations subsequent to the great flood of 1927. Prior to that, more limited responsibilities concerned the navigation of the Mississippi and Yazoo and other basin rivers, and the levee system along the western boundary of the Yazoo Basin.

45. The three major authorized project areas of the Corps within the basin are (1) the Yazoo Backwater Area, (2) the Yazoo Headwater
Area, and (3) the Big Sunflower River Basin, as depicted in Figure F13. Within each of these three areas, there are many individual projects for which the Corps is responsible and for which planning and design data are assembled on the basis of their pertinence to the specific projects.

46. The Corps subbasin boundaries do not necessarily correspond to any major topographic or geopolitical boundaries or to boundaries recognized by any other agency. For example, the Yazoo Headwater Area embraces the half of the basin occupied by the Upland Region, as well as that portion of the Alluvial Plain that lies east of the other two Corps subareas. Obviously there are important differences within this vast area in soil and water relationships, land use, land value, land ownerships, and human and institutional characteristics, and in problems and priorities associated with water and related land resources. The boundaries of the Yazoo Backwater Area were determined by the areal extent of backwater inundation by the Mississippi River during peak recorded floods; the distinct possibility for an even more extensive flood could conceivably necessitate a change in the boundary.

Soil Conservation Service

47. A recently completed report by SCS\textsuperscript{4} uses several different systems for subdividing the Yazoo Basin into planning units. None of the boundaries and tabulations are consistent with those used by the Corps or other agencies, and it is extremely difficult to correlate one system of subdivision by SCS with another by the same agency.

48. Much of this report is based on the delineation of three major physiographic regions of the basin, termed by SCS as land resource areas (LRA's), as follows:

a. LRA 131: Southern Mississippi Valley Alluvium.
b. LRA 134: Southern Mississippi Valley Silty Uplands.
c. LRA 133: Southern Coastal Plain.

The boundaries of these three LRA's are shown in Figure F14. The LRA boundaries are based on a combination of such factors as pattern of soils, topography, and type of agriculture for the purpose of broad agricultural interpretations.\textsuperscript{4}

49. The basin is also subdivided by SCS into 13 areas for the
Figure F13. Major authorized project areas of the Corps within the Yazoo Basin

1 LIMITS OF YAZOO BACKWATER AREA
2 LIMITS OF YAZOO HEADWATER AREA
3 LIMITS OF BIG SUNFLOWER RIVER BASIN

LEGEND

SCALE

10  20
0  10 MILES
Figure F14. Land resource areas delineated by SCS (from SCS4)
purpose of identifying watershed projects and certain other elements. These subareas correspond with major drainage systems. Areas 1-7 embrace the Big Sunflower River, Steele Bayou, and Deer Creek drainage; areas 8-13 consist primarily of the Yazoo River drainage, both above and below the bluff line, as shown in Figure F15.4

50. For operational purposes, SCS has delineated individual watershed projects in accord with authorizing legislation, and is reported in the agreement between the Corps of Engineers and SCS on Flood Protection and Related Programs in the Yazoo River Basin, Mississippi, March 1975,* as follows:

   a. PL-566 watersheds:
      (1) 8 projects completed - 664,168 acres
      (2) 2 projects under construction - 50,866 acres
      (3) 4 projects approved for planning - 368,680 acres
      (4) 4 projects approved by State Soil Conservation Commission - 858,749 acres
      (5) Total acreage of these PL-566 projects - 1,942,463

   b. Flood Prevention watersheds: 52 in operation of which 10 are in the skeleton plan stage, 1 is in review, and 3 are authorized for planning. Total acres - 3,180,027.

   c. Flood Prevention subwatersheds, Little Tallahatchie River watershed: 18 in operation, none authorized for planning, and no applications received. Total acres - 562,876.

   d. Total acres in all SCS watershed projects - 5,685,366.

This summary indicates that SCS small watershed projects cover 66.3 percent of the entire area of the basin.

51. All of the foregoing subbasin and small watershed delineations are very important not only to SCS, but also to the local Soil and Water Conservation Districts, watershed management districts, drainage districts, and the individual landowners who are involved in cost-sharing agreements. They are equally as important to the Corps of Engineers in view of the previously cited agreement between the two agencies, for the water from the SCS small watershed projects necessarily flows into the

* Interagency Agreement, between Corps of Engineers, Department of the Army, and Soil Conservation Service, Department of Agriculture on Flood Protection and Related Programs in the Yazoo River Basin, Mississippi, March 1975.
Figure F15. Areas delineated by SCS for identifying watershed projects (from SCS⁴)
four Corps reservoirs and into the main-stem channels whose management is within Corps jurisdiction. Coordination will be discussed in more detail elsewhere in this report, but the need for mutual understanding of these sub-basin and small watershed delineations and for the exchange of hydrologic and other data for planning, construction, and operational purposes is emphasized here.

52. In its report on the Yazoo Basin, SCS makes still another areal subdivision of the basin. The report states that "the basin was divided into different subareas for selected problems and needs and to make data appraisal more meaningful." The "selected needs" include water withdrawals for municipal, industrial, and rural domestic uses; thermoelectric power; irrigation; livestock; minerals; fish and wildlife; commercial fisheries; agricultural; forestry; and recreation and tourism. The six "special subareas" upon which tabulations are based are portrayed in Figure F16.

53. The statement in the SCS report that this subdivision makes "data appraisal more meaningful" is subject to conjecture. The boundaries that delineate the six subareas all follow county lines. These boundaries have justification since much published data are available only on a county basis, and county-line delineations have significance from a legal, political, and administrative point of view. However, the tabulations for each of the six areas embrace only 26 counties, with no consideration being given to four counties that are partially within the hydrologic basin. Furthermore, no rationale is presented for grouping the counties into these six planning subareas, except for "selected needs" and to make "data appraisal more meaningful." These subareas vary from a single-county area to a seven-county area, from municipal populations of 31,864 with 23 water systems to 93,560 with 52 water systems. These subareas correspond to no others that have been delineated for any other purpose. They can have no administrative or geopolitical relevance because of their unusual configurations and variable size. For example, subarea 5 is 121 highway miles from the south end to the north end, and subareas 2 and 6 are about as extensive. Data compilations based upon these subarea delineations are of no value.
Figure F16. Special subareas delineated by SCS for discussion of water and related problems and needs
to the Corps of Engineers in its basin planning effort.

54. The foregoing comments are intended to be an evaluation of the extent and availability of existing and needed data for comprehensive river basin planning. There is no intention to be critical of the delineations except to recommend that it would be to the advantage of all agencies and organizations and to the tax-paying public to standardize them.

Levee districts

55. The oldest and perhaps the most prestigious and influential subdivisions of Mississippi State Government are the two levee districts whose jurisdictions are outlined on the map of the Yazoo Basin, Figure F17. These districts, with funds derived solely from taxes upon the benefited property, made possible the civilized settlement of the Alluvial Plain for they constructed and maintained the original Mississippi River levee system and improved many miles of inland drainage ways long before there was appreciable Federal participation.

56. Boundaries of the levee districts adhere to county lines for the most part, the major exception being the Yazoo-Mississippi Levee District whose eastern boundary follows the base of the bluff line. These are important geopolitical subdivisions with a long and colorful history, vested with the power of eminent domain, the right to levy taxes on real and personal property, and the right to receive 50 percent of the State privilege tax on public utilities within their boundaries.

57. The levee districts were responsible for acquiring the right-of-way of the present 275-mile system of levees and holding it in perpetual ease for levee purposes, and for maintenance and control of the levees. On interior stream improvements, various arrangements exist; but generally on Congressionally approved Corps of Engineers and some SCS projects, the districts acquire perpetual easements and are responsible for maintenance, with the Federal agencies financing construction. Up to 1951, the two levee districts had locally raised and expended $65,186,000, compared with $107,893,000 by the Federal
Figure F17. Levee districts
Government, with most of the Federal expenditure occurring after the 1927 flood. 11,*

**Drainage districts**

58. Intertwining and overlapping with the previously cited districts and subareas of the Yazoo are 215 locally sponsored, financed, and operated drainage districts. Between 1888 and 1930, 115 drainage districts were formed in the Alluvial Plain and 100 in the associated Upland Region, and about 4500 miles of channel were constructed. 11,*

59. Regarding the 115 drainage districts in the Alluvial Plain and the 100 in the Upland Region of the Yazoo Basin, the Delta Council statements say, "these improvements were financed by local interests, each being a separate entity with separate taxing power. There was no over-all plan for drainage district organization or coordination, and in many cases, natural drainage patterns were not fully utilized or were even ignored. Individual and localized efforts to cope with flood control problems proved ineffective and the overriding importance of these problems led to the organization of levee districts."*

60. The formation and operation of these districts attests to the desire and determination of the inhabitants of the basin to solve their problems, in spite of the almost insurmountable magnitude of surplus surface water. More than $25 million was raised from benefiting property owners, long before there were Federal programs to assist. 1

**Soil Conservation Districts**

61. All of the Yazoo Basin is within the jurisdiction of Soil Conservation Districts, most of which are organized on a county basis. Created by local initiative and referendum in accord with State enabling legislation and administered by locally elected boards and by the State Soil Conservation Committee, these districts are the vehicle whereby SCS extends its technical assistance to the individual landowner and to corporations. Other U. S. Department of Agriculture agencies, as well as numerous other Federal and State agencies, cooperate with the SCS programs.

*Delta Council "Objectives and Goals for Land and Water Development," mimeographed report.
62. It is recommended that the Corps of Engineers' planning program for water and related land resources of the Yazoo Basin take particular cognizance of the enlightenment and experience of the officers of all of the Soil and Water Conservation Districts of the basin. It is also suggested that the Corps could benefit from observing the SCS's use of citizen participation and involvement in agency decisionmaking and in providing coordination with subdivisions of county and State government, which are, in turn, supported by membership associations who have legislative influence at State and national level.

Resource Conservation and Development Districts

63. Two Resource Conservation and Development Districts (RC&D) embrace all but seven of the Yazoo Basin counties. These were authorized by the Food and Agriculture Act of 1962 (PL 87-703) as a means for the U. S. Department of Agriculture to provide technical and financial help to these counties in conserving and developing their natural resources and for improvements in local enterprises such as agriculture, industry, recreation, and community development. SCS is the lead agency for this effort.

64. Figure F18 indicates the boundaries of these districts. The Northwest Mississippi RC&D was approved in 1966 and expanded in 1971. The Northeast Mississippi RC&D was approved in 1968 and expanded in 1973. It has been suggested by SCS that the seven counties lying between the two districts be annexed to the Northwest Mississippi RC&D.

65. It is recommended that all reports and documents of the two RC&D programs be acquired and that the Corps of Engineers Yazoo Basin planning effort take advantage of the local leadership and plans of these projects.

Delta Council

66. One of the most instrumental institutions in the furtherance of the economy of the Alluvial Plain of the Yazoo Basin is the Delta Council, founded in 1935. With its headquarters at the Delta Branch of the Mississippi Agricultural and Forestry Experiment Station in Stoneville, the Delta Council functions among other things as an
Figure F18. Resource Conservation and Development Districts (RC&D) (from SCS^4). SCS has suggested that the counties between the two districts be annexed to the Northwest Mississippi RC&D.
enlightened and aggressive regional chamber of commerce for the 18 counties that lie within the Alluvial Plain (Figure F19). The boundaries follow county lines, so the eastern band of counties also contains most of the Loess Bluffs and a small part of the Upland Region (compare with RC&D, Figure F18).

67. The Delta Council is totally supported at the local level, with funds being generated through membership subscriptions and through appropriations by the member county boards of supervisors. Initially its emphasis was upon the development of agriculture, which logically involved primary attention to alleviation of the flooding and drainage problems. For the past quarter of a century, the Council has taken aggressive leadership in the stimulation of industrial and related development to diversify the economy and to provide employment opportunities for the hundreds of thousands of former agricultural workers who were displaced by widespread agricultural mechanization following World War II.

68. This regional institution must be viewed as the most influential and reliable of all representatives of the western two-thirds of the Yazoo Basin. It is a close partner in every effort toward the enhancement of the economic and social well-being of the region.

69. It is recommended that consideration be given to expanding the jurisdiction of the Delta Council to include the other 12 counties that comprise the entire Yazoo Basin. This is justified on the basis of the necessity for correlating upstream water and related land management in the Upland headwaters area with the downstream management in the Alluvial Plain. Also, since three of the four large flood-control reservoirs are outside the present jurisdiction of the Delta Council, it is felt that the Council could give impetus to major tourism and recreational development as generators of wealth and employment as well as better satisfy the recreational needs of delta residents.

70. Should the Council's jurisdiction be expanded, it is conceivable that the Delta Council could be paralleled by a basinwide governmental entity along the lines of the conservancy districts of Ohio or the river authorities of Texas. This would provide for a
Figure F19. Boundaries of the Delta Council
bonafide and viable spokesman for the people, enterprises, and institutions of the entire Yazoo Basin. It could pave the way for a more effective effort toward public awareness and participation through elected representatives from all 30 counties of the basin.

71. The Delta Council has already performed outstanding public service toward coordination of the many echelons of involvement in water and related land management. Its technical advisory committee has been a rallying element in achieving communication and coordination. Its sponsorship of the Master Water Management Bill enabled the federation of several of the drainage districts into entities more capable of managing water on an area-wide basis and more capable of cooperating with the small watershed program of SCS and with Corps of Engineers programs.

Planning and development districts and councils*

72. The State of Mississippi is divided into 10 state planning and development districts (PDD), two of which are wholly within the Yazoo Basin and four of which include portions of that basin (Figure F20). Seven of these districts were created in response to the Public Works and Economic Development Act of 1965, and three were organized under the Appalachian Regional Development Act of 1965. These acts, along with other sources of Federal, State, and local funds, provide staff and technical assistance to achieve comprehensive planning for the districts as a whole and to encourage county and local planning.

73. The functions of the districts have expanded and shifted with the ebb and flow of Federal funding; but in addition to comprehensive planning, they are intended to help to function as clearing houses and to avoid duplication and overlap of various governmental programs; to keep the public informed about district programs; to improve regional

* Data for this section were obtained from the Community and Regional Planning Section of the Mississippi Research and Development Center (R&D Center) in Jackson, from a personal interview with the regional planner of the South Delta PDD in Greenville, and from the Atlas of Mississippi.13
Figure F20. Planning and development districts (from Reference 13)
and community programs in recreation, housing, education, transportation, the aged, and health; and to develop environmental controls. In addition, the northwestern portion of DeSoto County, which is in the Yazoo Basin, is also included in MATCOG, the Mississippi-Arkansas-Tennessee Council of Governments, which functions on the order of a regional planning commission for metropolitan Memphis and with offices in that city.

74. The boundaries of the PDD's that cover the Yazoo Basin appear to have been designed only for administrative convenience at the State level. They do not coincide with natural physiographic or watershed boundaries, with major trade area or labor pool boundaries, or with the boundaries of any other institutions or agencies discussed in this report or elsewhere. They are, however, important entities in the administrative and planning panorama of the basin.

75. All the published reports of the South Delta PDD, headquartered at Greenville, that had relevance to the basinwide planning program of the Corps of Engineers, were obtained and are a part of the U. S. Army Engineer Waterways Experiment Station (WES) data bank on the Yazoo Basin. These were obtained to illustrate the kinds of planning reports that should be obtained from the other five PDD's as the basinwide planning program progresses.

Local Comprehensive Planning Program

76. In the preceding section on the PDD's that blanket the basin and the State, reference was made to their function in relation to local planning within their respective jurisdictions. This section will present the status of county and municipal planning within the Yazoo Basin, with the implication that here too repose a great deal of data and expressions of professional planners and local leadership that are relevant to the basinwide water and related land resources plan. Most of the county and municipal planning has been accomplished through cost-sharing with the Section 701 comprehensive planning program funded by the U. S. Department of Housing and Urban Development and administered by the Community and Regional Planning Section of the R&D Center. In come cases the plans were developed by professional planning
consultants and in other cases by the staff of the PDD's.

77. As of mid-August 1975, 13 of the 30 counties of the Yazoo Basin had completed comprehensive plans. All were completed during the 1970-75 period except two that were done in 1964 and 1968 and have since been updated. Figure F21 outlines those counties with plans and the year of completion. A total of 64 municipalities within the Yazoo Basin had completed comprehensive plans by August 1975, as indicated in Figure F22. A key to Figure F22 giving the municipalities and the date of completion of each comprehensive plan follows.

1. Anguilla, 1971
2. Ashland, 1974
5. Benoit, 1974
6. Bruce, 1972
7. Byhalia, 1973
8. Calhoun City, 1974
9. Carrollton/North Carrollton, 1974
10. Cary, 1971
11. Charleston, 1974
12. Clarksdale, 1972, 1974
13. Cleveland, 1968, 1975
15. Como, 1973
16. Crenshaw, 1972
17. Delta City, 1971
18. Derma, 1972
19. Drew, 1971
20. Duck Hill, 1975
21. Durant, 1969
22. Friars Point, 1972
25. Grenada, 1971, 1975
27. Hollandale, 1973
29. Horn Lake, 1975
30. Houston, pre-1960
31. Indianola, 1972, 1975
32. Inverness, 1972
33. Isola, 1972
34. Itta Bena, 1965
35. Jonestown, 1975
36. Lambert, 1972
37. Leland, 1972
38. Lexington, 1973
39. Marks, 1972
40. Merigold, 1972
41. Moorhead, 1972
42. Mound Bayou, 1972
43. New Albany, 1971
44. Olive Branch, 1968
46. Pontotoc, 1968
47. Potts Camp, 1973
48. Ripley, 1971
49. Rolling Fork, 1972
50. Rosedale, 1972, 1974
51. Ruleville, 1967, 1974
52. Sardis, 1971
53. Senatobia, 1970
54. Shaw, 1972
55. Shelby, 1972, 1974
56. Summer, 1970
57. Sunflower, 1971
58. Tchula, 1972
59. Tunica, 1972
60. Vardaman, 1975
61. Vicksburg, 1970
62. Water Valley, 1971
63. Winona, 1967
64. Yazoo City, 1970, 1975

78. The majority of the municipal plans were completed during the 1970-75 period; most of the municipalities with earlier plans have subsequently updated them. Representative samples of most of these
Figure F21. County comprehensive planning status as of August 1975 (from the Community and Regional Planning Section, R&D Center)
Figure F22. Municipal comprehensive planning status as of August 1975 (from the Community and Regional Planning Section, R&D Center). See paragraph 77 for key to numbers.
county and municipal plans are on file at WES, especially those documents dealing with comprehensive general plans, land use, recreation, and capital improvements, as those subjects were deemed most germane to the study.

79. There appears to be a paucity of appreciation for the function of so-called comprehensive local and regional planning, for their components, and for their relation to administration and management. Such an understanding is necessary for effective evaluation of the many municipal, county, and regional plans assembled for the Yazoo Basin with the cooperation of the Mississippi R&D Center and the South Delta PDD.

80. To be eligible for Federal cost‐sharing assistance, with two-thirds Federal matching except in counties designated as being "economically distressed" in which case the Federal share is three-fourths of the total planning cost, a county must meet fairly rigid and uniform criteria in the performance of the planning task. These criteria include the creation of an actively participating planning body made up of private citizens residing in the planning area, the preparation of a series of basic studies designed to describe existing situations and forces of change (history, locational features, natural resources, land use, population, housing, public utilities, public facilities, traffic and transportation, economic base, and special studies pertinent to that community, county, or region), projections of these elements to the planning target year, preparation of a "comprehensive general plan" to be implemented through such devices as the 20-year (in 1- and 5-year increments) capital improvement program and budget, the "official map," subdivision regulations, a zoning ordinance, and other administrative and regulatory decrees and ordinances. For most communities this sequence entails a minimum of 2 years of hard work by the planning commission, advisory committees, and their professional planners. To be effective, the basic studies must be continually updated, modified, and subjected to public review. The diagram in Figure F23 has been provided to aid in understanding the logic and structure of such a planning process; this particular tool has
Figure F23. Structure of the planning process
been employed in over 50 community, county, and regional planning programs.

81. It is significant that of the 32 Mississippi counties that had completed comprehensive plans by mid-1975, 41 percent of them were in the Yazoo Basin. Of the 155 municipal comprehensive plans completed in the State, 41 percent were in the Yazoo Basin. Considering that the basin embraces only 28 percent of both the total land area and total population of the State and 37 percent of the counties, there appears to have been an aggressive push for county and municipal planning in the basin. The leadership and enlightenment generated by these 64 municipal and 13 county planning commissions should be employed in the basinwide water and related planning program of VXD in addition to the data contained in the hundreds of county and local maps and reports.

**Legislative and congressional districts**

82. The final example of the incongruity of the subdivision of the Yazoo Basin into component parts is the county-line gerrymandering of State legislative and congressional districts. As has been said of all the foregoing subarea delineations, these bear no resemblance to any other mode of territorial subdivision.

Of the 18 State house of representatives districts embracing the basin, 15 are totally with the 30-county basin. There are 11 State senatorial districts entirely within the basin and 3 embracing counties partially within the basin. There are four congressional districts that embrace portions of the basin, all including other nonbasin counties (Figures F24 and F25).

**Federal recreation areas**

83. Figure F26 summarizes the major recreational areas and facilities administered by the four Federal agencies with recreational and related programs operating in the Yazoo Basin. More will be presented of these facilities and programs elsewhere in this appendix; at this point the purpose is merely to establish the jurisdictions of the several agencies.

84. The principal Corps of Engineers facilities, on which recreation is really a by-product and ancillary to the prime project purpose,
Figure F24. State legislative districts
Figure F25. Congressional districts
LEGEND

CORPS OF ENGINEERS RESERVOIRS
1 ARKABUTLA
2 ENID
3 GRENADA
4 SARUIS

NATIONAL FORESTS:
A DELTA
B HOLLY SPRINGS

NATIONAL PARKS:
C VICKSBURG NATIONAL MILITARY PARK

NATIONAL WILDLIFE REFUGES
D YAZOO NWR

SCALE

Figure F26. Federal recreation areas (from Reference 14)
are the four reservoirs in the Upland Region of the basin: Arkabutla, Enid, Grenada, and Sardis. Although these are among the most spectacular of the Corps projects and the generators of the most recreational use (7 million users in 1974), virtually all other Corps projects in the basin are used in varying degrees by recreationists. A notable example is WES, at Vicksburg, which hosts an average of 25,000 recreational/educational visits each year.

85. The Forest Service of the U. S. Department of Agriculture owns and administers two national forests in the basin. The Delta National Forest with its 59,157 acres of Federally owned land has some of the outstanding specimens of bottomland hardwoods in the entire South. The Holly Springs National Forest, in two separate units, contains approximately 115,600 acres of Federal land to which the public has free access.

86. At the extreme southern end of the basin, the National Park Service of the U. S. Department of Interior administers the Vicksburg National Military Park. This 1800-acre park attracts an average of a half million visitors annually and is a major point-of-entry facility for people entering Mississippi from the west on Interstate Highway 20. The Natchez Trace National Parkway, although just outside the Yazoo Basin, is a regional recreational facility administered by the National Park Service that affects the entire area.

87. The Yazoo National Wildlife Refuge is a 12,000-acre area in southern Washington County. It is administered by the U. S. Fish and Wildlife Service of the U. S. Department of Interior.

State recreation areas

88. The map of major state recreation areas, Figure F27, represents the locations of three categories of recreation areas administered by two State agencies in the Yazoo Basin. The key to the map annotation, which follows, should serve as further elaboration of the succeeding paragraphs on the jurisdictions of the individual State agencies.

89. State parks within the basin administered by the Mississippi State Parks Commissions are as follows:

1. Wall Doxey State Park, Marshall County
2. John W. Kyle State Park, panola County

F59
Figure F27. Major state recreation areas (from Reference 14). See paragraphs 89, 90, and 91 for key.
90. **State Wildlife Management Areas** within the basin administered by the Mississippi Game and Fish Commission follow:

A. Sardis Upland Game Area  
B. Calhoun Wildlife Management Area  
C. Malmaison Wildlife Management Area  
D. Yazoo Wildlife Management Area  
E. Sunflower Wildlife Management Area  
F. Issaquena Wildlife Management Area  

91. **State Waterfowl Management Areas** within the basin also administered by the Game and Fish Commission, are as indicated below:

a. Arkabutla  
b. Sardis  
c. O'Keefe Farm  
d. Grenada  
e. Leflore County 16th Section  
f. Indian Bayou

**Other jurisdictions**

92. At the risk of repetition, there follows a more complete enumeration of agencies and organizations with concern and certain responsibility for land and water resources of the Yazoo Basin. At this point, no further comment will be made as to their respective scope and responsibility; their involvement in plan formulation and implementation is imperative to a coordinated effort. The following is a summary of the persons and organizations notified by VXD of the initiation of the study of the Yazoo Basin to illustrate the overwhelming magnitude and complexity of the task of seeking participation and coordination of efforts:15
93. **Summary of all notices.**

   a. 8 notices to Congressional interests (2 committees, 2 senators, 4 representatives)

   b. 64 notices to 12 Federal agencies

   c. 108 notices to 12 State agencies, 92 of which were to members of commissions and boards

   d. 351 notices to county and local officials, including county judges, sheriffs, agents, and chancery clerks of 29 counties; 145 members of county boards of supervisors; and 90 mayors of municipalities

   e. 15 notices to other interests, including 10 officers and staff of the Delta Council, 4 economic development districts, and one resource conservation and development district

   f. 197 notices to levee boards and 32 drainage boards

   g. 198 notices to postmasters

   h. 41 notices to chambers of commerce

   i. 10 notices to navigation interests

   j. 4 notices to railroad interests

   k. 20 notices to professional organizations

   l. 21 notices to sportsmen

   m. 49 notices to national conservation organizations

   n. 98 notices to news media (editors of 44 papers within the basin, 8 television stations, 45 radio stations, and one trade journal)

94. **Federal agencies notified.**

   a. Office of Management and Budget

   b. Department of Army (5 different agencies)

   c. Department of Agriculture (4 different agencies)

   d. Department of Commerce (6 different agencies)

   e. Department of Health, Education, and Welfare

   f. Department of Housing and Urban Development (2 offices)

   g. Department of Interior (8 agencies)

   h. Department of Transportation (4 agencies)

   i. Environmental Protection Agency (2 offices)

   j. Federal Power Administration

   k. Council on Environmental Quality

   l. Water Resources Council
95. State agencies and officials notified.
   a. Governor
   b. Public Service Commission
   c. Highway Commission
   d. Highway Department Director
   e. Forestry Commission
   f. Board of Health
   g. Park Commission
   h. Game and Fish Commission
   i. Agricultural and Industrial Board
   j. Research and Development Center
   k. Board of Water Commissioners
   l. Rivers and Harbors Association of Mississippi
   m. Economic Council
   n. Air and Water Pollution Control Commission
   o. State legislators

Synopsis of Subareas

96. The preceding maps and discussion have presented an overview of the manner in which 18 agencies and organizations have partitioned the Yazoo Basin for the purpose of administrating their particular programs that have various degrees of relevance to water and related land resources. The purpose for this presentation was to ascertain if there was any commonality in the manner of subdividing the huge basin and in addressing the water and related land problems; the conclusion is that there is none, that each agency and organization functions in its own perception of its mission, its own special manner of segmenting the basin into operational units, and its own spatial basis for amassing data for its own exclusive use.

97. There are numerous other public, quasi-public, and private institutions that have interests and programs in the basin that are pertinent to water and related land planning and development, as will be mentioned in the subsequent section on coordination. However, in passing, it is interesting to note that of the 18 here discussed, 5 are representatives of Federal cabinet-level departments, 3 are direct
agencies of State government, 6 are local or regional entities made possible by State enabling legislation or by State constitutional mandate, 3 reflect legislative and congressional patterns of apportionment, and 1 is a voluntary membership organization. Awareness of such patterns, mandates, and jurisdictions is vital if the planning efforts of VXD are to take advantage of existing institutions and minimize duplication and confusion.

98. It is recommended that early in the planning process, VXD initiate thorough studies of legal and administrative aspects of the management of water and related land and other resources for further resolution of the rights, constraints, and conflicts in the institutional arrangements. From such a study should emerge a more lucid basis for coordination and public participation and a better framework for plan development and implementation.
99. Programs of planned change for water and related land resources in the Yazoo Basin involve people as individuals and as groups, organizations, and communities. Unless thoughtfully planned, any water management programs may encounter resistance from those whose interests they are designed to serve. In some cases, established customs and institutions may be threatened, power structures and communication channels may be circumvented, or firmly held values may be challenged by development programs. In other instances, however, few if any conflicts occur; and programs are initiated, planned, and implemented efficiently.

100. It is imperative, therefore, that the planners develop and maintain an understanding of and sensitivity to the varied and interrelated elements of the social environment of the area, as well as the relationships between the social well-being and the other facets involved in the analysis of environmental quality, national economic development, and regional development. These four accounts, as delineated by the Water Resources Council, cannot be meaningfully separated. An impact could conceivably contribute to or detract from all four accounts. And an impact that is generally considered to be a part of the social environment (or social well-being) can affect the other three accounts. There are complex interrelationships between the four accounts that may never be completely or meaningfully untangled.

101. The measure of an analysis of social impacts is relevant to the planning process of water resource management programs if it can provide the information needed to enable the decisionmakers to appreciate the major dimensions and implications of the situation and to weigh the effects on one or another planning alternative. The assessment of social, economic, or political impacts should be viewed as a planning tool that seeks to provide planners and decisionmakers with a frame of reference for making planning decisions.

102. A consideration of the basic elements of the sociocultural environment to be included in investigation and analysis is in order. A simple delineation of data points is by no means sufficient, however.
The interrelationships of these factors are perhaps more important than any one of them considered separately. The basic sociological approach is to use these factors to identify and describe the social structures and then the processes that tie these structures together (not omitting conflicts, which may keep them apart).

103. The following delineation is presented in a rather static fashion. It should be remembered, however, that the elements presented are to be considered a part of the dynamic sociocultural system of the area.

Historical Data

104. As was evident in Part II, a large amount of data exists on the history and archaeology of the Yazoo Basin. The history of the basin should include a sufficiently extensive description of the area to allow for an understanding of the patterns and processes of the populations: specifically, the heritage of the area—archaeological, cultural, social, political, and economic—and its evolution into the current situation in the basin. As has been noted, an understanding of and sensitivity to the established customs and institutions, power structures, communication channels, and firmly held values may preclude conflicts in a program of planned change. Violations of or intrusions upon this heritage, whether or not they are recognized as such by the parties involved, will undisputably result in major if not insurmountable problems for the planners.

105. Facets of particular interest in the heritage of the Yazoo Basin include the rich archaeological resources and the history of existing water and land resource management programs in the basin. The agricultural evolution in the State of Mississippi as a whole as well as in the Yazoo Basin has and will continue to influence the social, political, and economic characteristics of the area. These inter-relationships, as well as the existing patterns, should be evident in the history of the basin. The history of the human resources should be delineated in such a way as to tie it meaningfully into the delineation
of baseline conditions and projections for the future population characteristics.

106. Data on the history of the Yazoo Basin covers the time periods from the first Indian tribes through the settlement by Europeans, territorial and early statehood, the Civil War, reconstruction, civilian rule, and the modern period. The *Atlas of Mississippi* is an excellent source of historical data on all of these periods, particularly the modern period and future projections, where many of the other references are lacking.

107. Socially, politically, and economically, Mississippi was little changed during the period from 1830 to 1890. Although political leaders and newspapermen had glorified the new age that, according to the leaders of the day, the people of the State were already in or were about to enter, the institutions and ideas dominating the scene in 1890 were hardly different from those characterizing the area two generations earlier. The population earned the same livelihood, farmed the same crops, and lived in the same places that they had 60 years earlier. The slavery system had been destroyed by the Civil War, but the status of the area's blacks had changed little. Economically, politically, and socially, the Negro in 1890 enjoyed only those rights that the white minority chose to give him.

108. In 1890, the area's economy was still overwhelmingly agricultural and based on only one chief money crop--cotton. The State's economic fortunes rose and fell with the price of cotton, as they had since 1830. The long-awaited trend toward crop diversification was still nearly two generations away. In addition, more and more of the area farms were tilled by sharecroppers, a system that had been developed after the Civil War as a means of dealing with the newly freed slaves. Yet by 1890, more and more sharecroppers were whites, the former small independent farmers who were losing their lands because of the combined pressures of debt, low cotton prices, and one-crop farming.

109. Demographic patterns in Mississippi were also essentially the same in 1890 as in 1830: overwhelmingly rural and agrarian. Slavery had become an institution in Mississippi in the 1830's when the Indian
lands in northern Mississippi were opened and cotton agriculture sub-
sequently boomed. In that decade alone the slave population soared
nearly 200 percent. By 1890 there were about six blacks for every four
whites in the population. Although slavery had disappeared by 1890, it
gave way only to political emasculation, segregation, and the economic
oppression of sharecropping for the blacks. Hence the status of blacks
had changed only in name.

110. Politically, the Populist movement produced some demands for
reforms. This was a movement that grew out of the small farmer's
grievance toward low prices, unresponsive State government, and the ex-
plorative characteristics of sharecropping. Although they failed in
achieving any deep changes in the basic institutions of the State, the
Populists voiced their discontent and showed that conditions need not
always remain the same. Their third-party labors did have some effect.
In the first two decades of the twentieth century, their efforts in-
fluenced the dominant Democratic party, and produced some significant
social and political reform. Between 1904 and 1920, a spate of legisla-
tion altered the economic, political, and social face of the State, at
least for the white population. Election law reform, tax equalization,
and greater support for public education were victories for the small
hill farmers. Despite these reforms, however, Mississippi as a whole
and the Yazoo Basin in particular entered the 1920's solidly in the
rigid controls of segregation. Blacks still outnumbered whites and the
area remained predominantly rural, agrarian, and unindustrialized.

111. If little progress was noted in the 1920's, the years of
depression of the 1930's were a complete disaster for the State. The
price of cotton dropped drastically and almost one-tenth of the farms in
Mississippi changed hands. The national relief programs of the New
Deal had little effect in what remained a nineteenth-century economy,
but some impact was felt. Many rural farmers obtained their first
electric lights because of the Rural Electrification Authority, and some
were able to buy their first farm machinery with Federal benefit pay-
ments under the Agricultural Adjustment Act.

112. Perhaps the most lasting effect of the Depression, however,
was on the agricultural sector of the area. It dramatically and irrefutably illustrated the grinding effects of one-crop agriculture based on sharecropping and the necessity of balancing agriculture with industry. Out of this realization and the efforts of the governor of Mississippi in 1936, the first serious, planned attempt to industrialize the economy grew. The Balance Agriculture with Industry plan provided the mechanics that the State and local governments could use to attract industry. Under its provisions local governments could issue bonds to build plants, which in turn were leased to industries. Such benefits coupled with tax exemptions began to pay immediate dividends.

113. Although some changes had occurred in the State between 1890 and 1940, they were largely superficial. The early 1940's found cotton still king and the mule and the sharecropper still visible. Segregation still kept Mississippi blacks in the social and economic back seat. The catalyst for real change in the State of Mississippi was World War II. The 4 years of war opened the area to the outside world, and for the first time the people were introduced to the fruits of prosperity. The war inevitably set in motion forces which over the next years altered fundamentally the institutions under which Mississipians live. The long-sought dream of agricultural diversification was finally achieved. The years since 1945 have marked the transition of the State from an agrarian society to an industrial and commercial economy.

114. The agricultural revolution after World War II was sudden and complete. Extensive crop diversification permanently dethroned King Cotton. The drive toward agricultural mechanization was an equally fundamental change, and it produced radical changes in farming methods. Greater centralization occurred, which was the end of sharecropping. No longer could farming be considered a way of life; it had become a commercial enterprise. Thousands of agricultural jobs disappeared: in 1940 more than one of every two jobs was in the agricultural sector; twenty years later, fewer than one in every five was in agriculture. Not only did cotton lose its throne to other products, but agriculture lost its primacy in Mississippi's economy, although this trend was not so prevalent in the Alluvial Plain.
115. The last of Mississippi's ties with its past—segregation—was broken but not without the great emotion and some violence that often accompany fundamental social changes. Segregation had been substituted in the late 1800's for the social control over blacks that slavery had afforded. This had been strengthened and crystallized into law through the first four decades of the 1900's. Segregation finally came under attack in the 1950's and 1960's from the black-led civil rights movement and the Federal Government. Mississippian did not easily relinquish their last institutional tie with the past. Yet by 1970 the State's blacks enjoyed more freedom, economic prosperity, and opportunity than ever before.

116. It cannot be concluded that the past is altogether dead in Mississippi. One by one, however, in the last three decades all of the basic themes of the previous 100 years have been altered: King Cotton, agrarianism, sharecropping, segregation, and a feeling of alienation and insulation from the world outside. In their places by 1970 have come modern transportation and communication, industrialization, diminution of the race question, agricultural diversification—issues not unlike those in other states. The Yazoo Basin has perhaps been slower than the rest of the State in accepting these trends; but even in this area, the inevitable progress is occurring.

117. Supplementary material on the history of the basin is available from several other sources. Additional references are listed in the Bibliography under "Historical References." Evidence of the impacts of past events upon present situations and attitudes will be noted throughout the delineation of the sociocultural characteristics in this section. These interrelationships should be clearly understood in order to allow for the enhancement of plans for the future.

Archaeological Data

118. An integral part of the heritage of the human population of the Yazoo Basin is evidenced in and should be preserved in the sites of archaeological importance throughout the area. Several fairly
comprehensive surveys and listings of the archaeological resources of the basin are available, particularly the Lower Mississippi Region Comprehensive Study, Appendix P, "Archaeological and Historical Resources," and the Archaeological Survey in the Lower Yazoo Basin, Mississippi, by Philip Phillips.

119. Although the Lower Mississippi Region Comprehensive Study notes that there are "great gaps in the knowledge of the total prehistoric occupation" of the basin, this is not seen as a research need in the current effort. A substantial amount of archaeological research has been done in this basin and over 700 sites are on record. The Mississippi Statewide Comprehensive Historic Preservation Plan includes archaeological resources. There are available lists of archaeological sites by county in the Lower Mississippi Region Comprehensive Study, and the Corps of Engineers itself has and may be currently surveying these resources on the upper Yazoo and Tallahatchie Rivers and the lower Yazoo as part of an environmental assessment of areas surrounding proposed drainage and channelization projects. Work in the area has been done recently by Mississippi State University, Starkville, and the Mississippi Department of Archives and History in cooperation with the Corps of Engineers and SCS.

120. In summary, most of the data needed to assemble a baseline study of archaeological resources has previously been collected. The main effort required in this area would be to compile and synthesize the existing information and integrate this synthesis with the overall plan for the basin. This would ensure that any planned land alteration may be preceded by detailed archaeological work. All efforts should be directed toward preserving as many of these resources as possible and recording a maximum of information from any sites that must be destroyed.

Demographic Data

121. In the inventory process that precedes planning, it is necessary to analyze the population of the area under consideration. Some of the past trends have been described and others will be included
in this section. Also required in order to describe and characterize the current social system in the basin are the major demographic features of the population: age and sex distribution, population mobility and displacement, ethnicity, density patterns, housing, and employment and income characteristics. A complete understanding of the Yazoo Basin will include further information on the economy and other community facilities and utilities that make the system function, including educational, religious, and health facilities; recreational and cultural opportunities; transportation and communication patterns; and agricultural and industrial patterns.

122. Much of the data needed to fill in these characteristics of the Yazoo Basin exists in some form. Most of the problems with its synthesis may lie in the various levels of specificity and detail. Most sources give data at least by county; although in some cases, the State is the basic unit of analysis. Other kinds of data are available for cities and towns of various sizes.

123. The *Atlas of Mississippi* \(^{13}\) covers many of the characteristics of the population: number, distribution, density, change, migration, age structure, ethnicity, rural populations, and urbanization. Most of the textual material is presented in terms of the State as a whole. There are maps accompanying most of the topics, however, that illustrate the characteristics by counties. These maps could be used to advantage in describing some of the characteristics of the people of the Yazoo Basin. In addition, one table is presented on population and land area for the State and each county. The cited sources of the maps presented should also be of use: the U. S. Census of Population and Rand McNally's *Atlas and Marketing Guide*.

124. Population trends by county in the basin since 1870 are shown in Table F1, with a comparison of the 1975 population to the peak population in previous years. Other types of similar data are available from the *Mississippi Statistical Abstract*. \(^3\) The population projections for 10 counties in the Alluvial Plain in the *Atlas of Mississippi*\(^{13}\) indicate a continuing decline. The Alluvial Plain has been rapidly losing population for many years and the trend is expected to continue.
In these 10 counties, the total population has declined by about 85,000 people in the last 20 years, with the loss largely in its black population. The trend will continue over the next 20 years with whites beginning to outnumber blacks in these counties during the 1980's. The total population of these 10 counties should decline to below 250,000 by 1990.

125. In Appendix B, "Economics," of the Lower Mississippi Region Comprehensive Study, a table is presented that shows that the population of the Yazoo Basin has declined continuously from the 1950 figure of 756,070 persons. A decrease of 10.8 percent occurred between 1950 and 1959, the period of greatest decline, as the population fell to 674,398. The downward trend continued through 1970, resulting in a decrease of 5.4 percent during the 1959-70 period and a 1970 population of 638,000 (approximately two-thirds of which was rural). Although the decline has been continuous since 1950, the rate of decrease was less than 0.5 percent annually between 1959 and 1970, as compared with 1.2 percent during the 1950-59 period.

126. Based on projections by the Office of Business Analysis and Economic Research Service (OBERS), the decline in population for the Yazoo Basin has reached, or is nearing, the point at which the downward trend will be reversed. A primary factor aiding this reversal is that the migration of displaced farm labor to areas of employment, one of the principal causes of population loss, has expended most of its influence. Thus, the past has been a period of population loss for the area, and the present is essentially a period of stability. During the projection period, however, substantial increases are expected. Some projections indicate that the decline is presently being reversed, and others show a continuation of the decline through 1980 but an increase thereafter. Although an increasing rate of growth is expected, it will remain below that of the Nation and the rest of the Lower Mississippi Region.

127. More detailed data for the population characteristics of the Yazoo Basin are available from the United States Bureau of the Census, specifically, the first- and fourth-count census tapes and the
Bureau of Labor's detailed manpower indicators tape. Information for an extended period of time is available as follows:

a. Population density as population per square mile.

b. Population mobility as the number of people who moved into a unit in the last 5 years and the number whose residence is the same as 5 years before.

c. Housing as value count, rent count, percentage in one-unit structures, and percentage in structures built in 1960 or later or in 1950 or earlier.

d. Crowding as number of units with 1.01 or more persons per room.

e. Transportation as the number with one or more automobiles, those who use public transportation to work, and those who work outside county of residence.

f. Desirable community growth as vacancy rate and median income.

g. Basic data on ethnic, age, sex, and educational attainment distribution.

These data are available on at least a per-county basis for the Yazoo Basin.

128. Recently compiled (1974-75) information is available from the R&D Center in Jackson, Mississippi, for individual communities and individual counties in the forms of "Community Data Sheets" and "Quick Reference Data Summary for Counties." The Community Data Sheets are an excellent source for community characteristics and facilities. They contain the following data for each town:

a. Location.

b. Population figures for 1950, 1960, and 1970 for the city and the county, including the percentage of nonwhites, and an estimation of the population within a 30-mile radius.

c. Transportation data, including highways, railroads, bus service, motor freight carriers, air service, waterways, and parcel service.

d. Financial institutions, as the number of banks and savings and loans and their assets.

e. Communication facilities, including newspapers, radio stations, television stations, telephone service, telegraph service, and post office class.

f. Information on the type of government, including police and fire protection.
g. Utilities and services, including electricity, water, natural gas, fuel oils, liquified petroleum gas, sanitary sewer and treatment plant types, storm sewer, and garbage disposal.

h. Recreational opportunities.

i. Labor force (on a county basis), including estimated number of workers, number of males and females employed, percentage involved in manufacturing, and number of local high school graduates employed.

j. Educational facilities, including public schools, private or parochial schools, vo-tech schools, colleges, and public libraries.

k. Health care facilities.

l. Churches.

m. Hotels and motels.

n. Tax situation, including manufacturer's property taxes and local nonproperty taxes.

o. Climate.

p. Major manufacturing employers.

q. Available industrial properties.

129. The Quick Reference Data Summary available for each county could also be of use in compiling a baseline profile of the population of the Yazoo Basin. The following information is included:

a. Population data include 1960 and 1970 populations; the percentage change for the total, the black, and the white populations (includes an "other" category as well); the U. S. Bureau of Economic Analysis (BEA) population forecast for 1990; one of several population forecasts for 1990 and its source; and the number of cities with over 1000 population, their 1970 population, and again the percentage change from 1960 to 1970.

b. Income information for the years 1959 and 1969 is broken down by median family income, median income for families and unrelated individuals, percentage of families below poverty level, and the BEA figures for per capita income for 1971 and the total personal income for 1971. The major sources of personal income (BEA) for 1971 are broken down by category and percentage of total, including agriculture, net transfer payments, government, manufacturing, and property income, and the average weekly wage from the Mississippi Employment Security Commission (MESC).
c. Information on manufacturers includes 1973 data on manufacturing employment from MESC; a list of the five largest manufacturers from the Mississippi Manufacturers Directory; and the number of employees, type of product, and the number of manufacturing plants in the county, broken down by size and number of employees.

d. Information is listed on education levels and facilities, including (in 1970) the median number of school years completed and the percentage of high school graduates for the total population and the black population broken down by sex, and the number of public school systems and junior and senior colleges.

e. Information on employment includes the employment of county residents for 1960 and 1970 broken down by type, the percentage unemployment, the employment participation rate, the place of work (1970) whether in the county or outside it, and the number of females employed in manufacturing.

f. Information on sales in the county includes total retail sales for fiscal year 1973 broken down by type, total wholesale sales, and the public utilities.

130. A compilation of these data will be useful not only for providing demographic characteristics, but also in providing political and economic characteristics and indicators through which to monitor change. It will be noted that since 1870, the Yazoo Basin has experienced both growth and decline, its peak population year being 1940. In the 1960's and 1970's, the percentage of blacks in the population has been decreasing. Other population trends include a decreasing birth rate, large out-migration, and an increasing number of urban residents, although there are still seven counties in the basin with no urban residents. The two least-populated counties in the State--Issaquena and Benton--are both within the Yazoo Basin. Although one of the counties with the largest percentage increase from 1960 to 1970 was in the basin (DeSoto with 50.2 percent), its rapid growth was influenced by its proximity to the rapidly growing metropolis of Memphis, Tennessee. Most of the population losses occurred in the Alluvial Plain. Tunica County showed the largest percentage decrease, followed by three other Alluvial Plain counties--Quitman, Humphreys, and Issaquena--all with percentage decreases above 20 percent. Much of the decrease in this region can be attributed to the out-migration of blacks.
131. As far as age distribution and fertility rates, the Alluvial Plain counties have a high percentage (mostly around 40 percent) of residents under 18 years of age and a correspondingly high fertility rate. A high fertility rate is often influenced by other factors, which are also prevalent in the Alluvial Plain: low educational attainment, high percentage of rural population, large percentage of persons with incomes below poverty level, and a small number of people engaged in manufacturing.

132. The percentage of blacks in the population of the Alluvial Plain counties is high relative to the rest of the State. Ten of the thirty counties have black populations exceeding 60 percent. And in 1970, according to the Bureau of Census, 55.5 percent of the State of Mississippi's population was considered rural. As might be surmised, the counties with the highest percentage of rural farm populations were in the Alluvial Plain (Tunica, Tallahatchie, and Sharkey). Correspondingly, only 6 counties have urban populations exceeding 50 percent, while 12 of the Yazoo Basin counties have a rural nonfarm population greater than 50 percent.

133. To summarize, most of the counties in the Yazoo Basin have been losing population for years, but this trend is expected to slow if not reverse, although the projections in the Atlas of Mississippi for 10 Delta counties call for continuing population decline to 1990, attributed largely to the black out-migration. Most of the data needed to formulate a baseline profile for the basin exists and needs only to be compiled and synthesized.

Attitudinal and Political Data

134. Along with the objective data needed for the demographic profile, more subjective data are needed to complete a profile of the basin or to come to an understanding of its people. These subjective data may also be of use in facilitating plan implementation. A large amount of the data needed here has been mentioned previously. Additional needs may be obtained from still other existing sources, while
some of the data will have to be generated carefully.

135. Legal and political characteristics of the Yazoo Basin should be derived from data including types of municipal finance, political jurisdiction, voting patterns, tax burdens, and law and code enforcement. Also included in this section should be information on water rights, land-use controls, and jurisdictions of relevant agencies and organizations. Of particular interest in attempting to characterize the attitudinal and political facets of the Yazoo Basin population are the relationships, patterns, processes, and interactions of and between individuals, groups, and organizations. Channels of influence and communication are critical both to the baseline profile and the facilitation of implementation.

136. As was previously noted, most of the objective data required for this section exists and needs only to be compiled and synthesized. Descriptions of State government; State budgets and finances; county government; municipal government; school districts; political parties and voting patterns; the voting rights act; planning and development agencies, districts, and councils; State waterway districts; public and private industrial development districts, councils, and groups; and the port authorities and chambers of commerce may be found in the Atlas of Mississippi.13

137. Of particular interest in plan development and implementation are government and politics on county and municipal levels. County government in Mississippi consists of numerous elected officials, largely independent of each other, run by a county board of supervisors elected from districts. Municipal government may be one of three types: mayor-council, commission, or council-manager. Data about which communities have which types are available from the Community Data Sheets described in the previous section.

138. Information on the capabilities and jurisdictions of relevant organizations and agencies is also available. Much of this was presented in the earlier sections of this appendix and will not be reiterated here. It is sufficient to note that the information exists and needs only to be compiled and synthesized.
139. It is the subjective area of politics and attitudes that may, in the end, be critical to the success or failure of any program of planned change in the Yazoo Basin. How people feel about change in general as well as specifically proposed changes; what kinds of activities have been carried on in the past or are occurring now directed toward solving water and related land resource management problems; what kinds of patterns and processes exist in these activities; what the relevant channels of influence and communication are in the area; what kinds of interactions occur, both internally and externally, in agencies and organizations that could affect the issues; these are the kinds of things that must be investigated to complete a baseline profile of the basin. This kind of data can be obtained through carefully designed research tasks, using existing data and supplementing and enhancing it by defining and delineating the notion of process. The totality of this section, then, requires a combination of synthesizing existing data and generating new, then typing the whole together.

Economic Data

140. Economic data and projections cannot be isolated from the other types of information in the previous sections without a considerable loss of meaning and usefulness. To do so would entail numerous duplications of effort and a tendency not to recognize the web of interdependencies upon which the people, enterprises, and institutions of the planning area are so delicately balanced. There exist intricate and inextricable interrelationships between the economic characteristics and those relating to social and cultural attributes, institutions, and agencies involved in resource management, land use, and the entire realm of parameters that must be integrated into the planning process. With these things in mind, the data needed to assess the economic baseline profile characteristics and to project future conditions may be described.

141. Several indicators of economic growth or decline have been mentioned previously in the section "Demographic Data." These will be
mentioned again along with additional considerations for analysis of the economic characteristics of the population of the Yazoo Basin. Basic characteristics that should be analyzed include employment patterns and status, industrial development, agricultural development, personal and per capita income, total and per-worker earnings, activity of financial institutions, and sales figures.

142. As was noted earlier, data on employment, income levels and sources, wages, manufacturing, and sales are available on a per-county basis in the form of the Quick Reference Data Summary prepared by the R&D Center in Jackson, Mississippi. Their sources include BEA and MESC as well as the U. S. Census of Population and the U. S. Department of Commerce. Sales data were obtained from the Mississippi State Tax Commission. Additional information was obtained from the Mississippi Manufacturer's Directory. More specific data on the agricultural sector are available in the U. S. Census of Agriculture as well as various publications of the Mississippi Agriculture and Forestry Experiment Station.

143. The Atlas of Mississippi\textsuperscript{13} gives economic information for the State as a whole as well as broken down graphically by counties. It is noted that although personal income rose about 7 percent in Mississippi in 1970 (almost equalling the national increase of 7.5 percent), the State does have economic problems. In per capita income, Mississippi ranks lowest among the six states of the southeastern region, and Mississippi's average income of $2757 per person in 1970 was substantially below the Nation's $3921 and the southeastern region's $3204. Since the 1940's, per capita personal income has uniformly increased in Mississippi. Impressive as the sustained growth of per capita income has been in Mississippi, many more years will pass before the State's per capita income approximates the national average.

144. The mean (average) income of families by counties in 1969 indicated a considerable degree of variance among areas of the State. Of the 30 counties in the Yazoo Basin, only two, DeSoto and Warren had a mean family income between $8,000 and $9,000; all others were below that and no county in Mississippi equaled the national average.
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family income. Despite some growth, in the early 1970's a sizeable minority of Mississippi's population remained poor. In 1969, over 35 percent of the State's population was below the poverty level, almost three times the national average. The ethnic division accounted for a large weighting factor, because 65 percent of the black population lived below poverty level, while 18 percent of the white persons were so classified. The age distribution was also a factor in that 55 percent of persons 65 and older had incomes below poverty level. Three counties in the Yazoo Basin--Holmes, Humphreys, and Tunica--showed 50 percent or more of their families living on a mean income of less than $3,000 (well below poverty level). The Alluvial Plain, with its high density of black residents, has a high poverty index relative to other areas of the State.

145. Predictions for the future of the State indicate continually increasing per capita income. Manufacturing, already the largest source of income in Mississippi, should continue to gain in relative importance. The State will remain basically a "small town" state, favoring development of manufacturing over tertiary or service activities. Agricultural output will continue to increase moderately, but the greatest progress in agriculture will be more labor-saving efficiency, enabling the land to produce the same value crop with less employment. Agriculture will, therefore, provide an improved standard of living for those engaged in it, but the number engaged will decline.

146. Employment in Mississippi will increase as a result of the continued growth in nonagricultural employment combined with the "bottoming out" of employment in agriculture. As total employment rises, wage rates will also increase. The projected gain in manufacturing in the State will spearhead the economic growth. The type of manufacturing in the State will begin to change from predominantly labor-intensive operations to more capital-intensive industries. The heavier, more capital-intensive industry will concentrate in water-accessible locations: on the Gulf Coast, on navigable water in the northeast, and at Mississippi River ports.

147. It is likely that farming in Mississippi will continue to
shift from dependence on cotton toward food crops. Food-processing operations will gain in importance. Use of marginal land for pasture and crops will increase.

148. In the Yazoo Basin itself, the development of manufacturing and agriculture will continue to develop. Appendix B, "Economics," of the Lower Mississippi Region Comprehensive Study indicates that the value added by manufacturing increased 69 percent between 1963 and 1967. In 1967, there were 569 manufacturing establishments in the area with a combined payroll of $156.6 million. These firms employed 34,200 people, 28,200 of whom were production workers. Forty-one percent of the establishments employed 20 or more workers, while 16 percent had more than 100 employees.

149. The value of gross production by manufacturing increased 8 percent from 1967 to 1968, and manufacturing accounted for over 21 percent of total earnings in the basin in 1968. The larger contributors to total manufacturing earnings included textile mills products, food and kindred products, chemical and allied products, lumber and furniture, machinery manufacturing, and apparel production.

150. Since fertile agricultural land is one of the most valuable resources of the Yazoo Basin, it is not surprising that agriculture is the most important part of the area's economy, as reflected in earnings and employment values. For example, agricultural earnings of $249.3 million in 1959 represented 36.6 percent of total earnings. These earnings increased to $258.9 million in 1968. Although agricultural employment declined due to substantial mechanization, it accounted for 36.3 percent of total employment in the basin in 1960, the largest contribution to total employment by a single industry.

151. Land in farms accounted for 71.8 percent of the land area in the Yazoo Basin in 1970, 8 percent less than in 1949. A continuation of this downward trend is anticipated in the future. More dramatic changes occurred in the number of farms in the area, as reflected in the 50-percent decrease in number of farms between 1959 and 1970. While the number of farms declined in 1970, average farm size increased from 152 acres in 1959 to 296 acres in 1970. Soybeans and cotton are the
principal crops harvested in the basin. Combined, these two crops accounted for 87.1 percent of total crop acreages harvested in 1970. Other crops contributing to the total were hay, corn, rice, wheat, and oats. The most notable decreases in acreages between 1959 and 1970 were in cotton, corn, and oats; significant increases occurred in soybeans and wheat.

152. Employment in the Yazoo Basin declined from 243,700 in 1950 to 208,500 in 1959, but rose again to 231,000 in 1968. These values reflect a decrease in employment of 14.4 percent between 1950 and 1959, but an increase of 10.8 percent from 1959 to 1968. The decrease during the earlier period reflects the loss of employment as agriculture adopted more mechanized methods. The technological strides in agriculture contributed to losses in agricultural employment that were not offset by increased employment in other industries. The influx of manufacturing into the basin during the 1959-68 period, accompanied by a lessening in agricultural employment losses, resulted in a reversal of the downward trend in employment.

153. In 1960, agriculture and manufacturing were the two most important industries as far as employment is concerned in the Yazoo Basin. They accounted for 36.3 and 12.7 percent, respectively, of the total employment in the area. Agricultural employment declined 45.6 percent from 1950 to 1960, while manufacturing employment increased 85.9 percent during that period.

154. As was noted previously, total personal income increased by 70.3 percent in the period from 1950 to 1968. Eighty-three percent of this total increase occurred in the period 1958-68. The annual growth rate between 1950 and 1959 was only about 1.3 percent, restricted partially by the negative effects of decreasing employment and population. Between 1959 and 1968, however, personal income increased 4.7 percent annually due to a combination of factors such as the increase in employment and greater use of skilled labor in more capital-intensive industries. In terms of per capita income in the Yazoo Basin, the area has been below the national average, as is the entire State of Mississippi. Since 1950, however, it has steadily made significant
gains, which in recent years can be attributed more to absolute increases in total personal income and less to population losses.

155. Total earnings in the Yazoo Basin have also been increasing; 60.9 percent from 1950 to 1968. Again, 79.2 percent of this increase occurred during the period 1959-68. Even given such large increases, the annual growth rate was below that of the Nation for the entire period. Earnings in agriculture and manufacturing accounted for 26.6 and 21.1 percent, respectively, of the total earnings in the basin in 1968. This differs substantially from the 46.8 and 7.6 percent for agriculture and manufacturing in 1950. This change is indicative of the changes that occurred as the area moved toward a more manufacturing-oriented economy. Agricultural earnings seem to have reached a relatively stable level for the present, but manufacturing earnings are expected to continue increasing. Major contributions by other industries to total earnings in the basin in 1968 were made by Government, wholesale and retail trade, and services. These and other industries are expected to continue their current trend of accounting for large shares of total earnings.

156. In summary, the main economic problems in the Yazoo Basin are low income levels and underemployment. In general, basic changes in the economy of the area have been similar to those in many of the traditionally agricultural areas of the Lower Mississippi Region. The overall changes reflect a movement from labor-intensive to more capital intensive industries, a result of which has been a significant change in the employment base of the area. It appears that much of the change has already occurred and that basic trends have been or are presently being set. Although regional development programs can aid in the economic development of the basin, it is generally felt that the broad, basic nature of the changes that are occurring necessarily involves a substantial time period. Compilation and synthesis of economic data for the basin should be accomplished simultaneously with that for the other types of data. The interrelationships between the economic characteristics and those relating to social and cultural attributes, institutions, and agencies involved in resource management, land use, and
other parameters all should be explored and understood in order to facilitate the planning process and assess its impact.

157. In the process of systematically reviewing existing knowledge of the sociocultural resources of the Yazoo Basin, the previous delineation is the data that should be available to permit the basin planner to evaluate properly the impact of such factors on water resource problems as they arise. It should be noted that much of these data and their collection overlaps or interfaces other types of data or could provide data that would be useful in other sections of this report. No rigorous attempt has been made here to note all such overlaps, although several of the more obvious instances were mentioned. It is recommended that these data be collected and presented in such a manner that the data may be included in the computer-based resource information system suggested in Appendix E. Such an inclusion would greatly enhance the viability, meaningfulness, and usefulness of the data collected for the resource planning process.
PART VI: PROBLEM IDENTIFICATION AND DATA GAPS

158. Throughout the discussion of the sociocultural resources of the Yazoo Basin, certain problem areas have emerged: first, consideration of the planning process for the basin in a realistic perspective; second, aspects of jurisdiction, organization, and administration of a water resource planning program; third, identification and preservation of irreplaceable cultural resources; and fourth, an understanding of the characteristics and needs of the people of the basin. A discussion of these problem areas should facilitate a constructive approach to the planning process for the Yazoo Basin.

159. Consideration of the planning process for the basin in a realistic perspective involves investigating the attributes, problems, and potentials of the area in relation to other areas. The relationships that should be considered are national, state, regional and inter-regional, and metropolitan or urban. The basin also needs to be considered as a part of the larger Mississippi River system. The conditions and influences of each of these interrelationships affects the people of and the plan for the Yazoo Basin. As was noted in the section of this appendix on regional and other relationships relevant to planning, data exist on which this investigation could be based. The primary factor here is to stimulate inquiry and thought into the realistic assessment of the attributes, problems, and potential of the basin in relation to the larger system.

160. A second problem area that emerged from the discussion of basin and sub-basin boundaries was that of jurisdiction and organization of a water resources planning program. A plan could hardly be developed, much less implemented, without an understanding of the existing agencies and organizations within the basin. If the planning effort is to take advantage of existing institutions and coordinate efforts with other agencies, an awareness of the patterns, mandates, and jurisdictions in the area is necessary. Much data exist for this problem area, but there is a need for thorough studies of legal and administrative aspects of the management of water and related resources.
for further resolution of the rights, constraints, and conflicts in the institutional arrangements. From such a study should emerge a more lucid basis for coordination and public participation and a better framework for plan development and implementation.

161. The third problem area is that of identification and preservation of irreplaceable cultural resources. The Yazoo Basin, as well as the whole State of Mississippi, may be proud of the rich heritage of its people. From the early Indian tribes through the State's role in the Civil War, the area is the site for many reminders of an important past. Many authentic relics still exist and should be identified and preserved for future generations to enjoy. These include sites of archaeological significances such as Indian mounds and sites of historic significance such as battlefields and antebellum homes. Much data exist in this area, but there is a need for a comprehensive compilation of information into a useful form for the planning process to consider.

162. The remaining problem area is of a general nature: the characteristics and needs of the people of the Yazoo Basin. For any program of planned water resource management to be successful, however, these are a vital considerations. The public participation aspect of the planning process is critical to development and implementation. If the needs and goals of the people for whom the plan is designed are not known, the whole exercise becomes irrelevant. And if a plan is designed without consideration for the characteristics of the human population, the resulting impacts may be disastrous for all concerned. The planning process must take into consideration the social, political, and economic characteristics of the people in order to enhance development of the basin, not destroy it. Much data exist in this area, but much more needs to be collected and generated through quantitative and qualitative research techniques in order to understand fully the characteristics and needs of the human resources of the Yazoo Basin.
163. The following paragraphs present suggested research tasks that would allow for completion of a baseline profile of the Yazoo Basin and assessment of future impacts. Suggestions are made as to research organization, and estimates are made of the effort that will be necessary to conduct and complete research to eliminate existing data gaps. What is presented here is a list of suggested research projects that may overlap with research suggested by other members of the team. Better definition and integration can best be accomplished as the study develops.

Historical Characteristics

164. As has been stressed previously in this section, an overview of the history and the resources it has provided in the Yazoo Basin is necessary to gain an understanding of the area today. The following studies are suggested to fulfill this need.

Cultural history

165. The social, political, economic, and demographic history of the Yazoo Basin should be investigated in order to analyze and present the trends and critical influencing factors on the area today. Most of this information exists in several forms and several places. The main effort required would be to assemble and synthesize available data to form a meaningful background for the current research efforts. This could be accomplished by one or two social science professionals with assorted technical assistance, in conjunction with or as a prelude to current investigations.

Archaeological sites

166. The cultural resources of the Yazoo Basin include many sites of historical and archaeological value. These are well documented and a catalogue of those sites in the Yazoo Basin would require the expertise of one professional to assemble and present the information in meaningful form.
Demographic Characteristics

167. To provide baseline information from which to provide projection against which to analyze impact, several types of investigations are suggested.

Population characteristics

168. The general population characteristics needed to form a baseline for impact evaluation, to constitute a part of the area profile, are available in various forms from several sources and covering relevant time periods: the U. S. Census of Population, the U. S. Census of Housing, and the Bureau of Labor's detailed manpower indicators, as well as state and county records. The researcher needs then to assemble the relevant data according to the previous delineation in the "Demographic Data" section and to synthesize it to form a description of the current population in the Yazoo Basin.

Organizational and institutional characteristics

169. A description of the organizations and institutions that exist in the basin as well as their activities and the opportunities they provide is a necessary part of the baseline profile of the area. Again, much data exist for this profile and may be obtained from sources such as state and county records, selected agency information, and archive information. Data should be assembled and presented in conjunction with the other data to form a part of the baseline profile.

Attitudinal and Political Characteristics

170. The investigation of attitudinal and political characteristics of the Yazoo Basin involves both the objective aspects of organization and jurisdictions and the subjective aspects of the attitudes and patterns and processes of interaction within the population.

Legal and political characteristics

171. For effective management and implementation of any resource program, an understanding of the existing legal and political
characteristics is mandatory. This should include finance, jurisdictions, voting patterns, tax burdens, and law and code enforcement procedures. Without an appreciation of these resources in the Yazoo Basin, any program of planned change will be handicapped. An investigation of these characteristics will require a moderate effort by a social science professional to assemble existing data relevant to the topic, as well as to conduct interviews with knowledgable informants to get at the more informal, subjective aspects.

Patterns and processes of influence

172. In order to facilitate effective public participation as well as efficient management in water resource program, an understanding of the patterns of influence and interaction within and between various levels of organization in the Yazoo Basin is necessary. Maximum levels of local contribution to a water resources project could be encouraged by structuring the project to make use of existing networks of generalized leadership in the area.

173. To accomplish an understanding of the networks and patterns in the basin will require a reliance on systematically collected and synthesized qualitative data. In this area particularly, a sensitivity to the "ruralness" of the basin is necessary. Methodologies usually successful in urban areas may not be applicable to rural areas. Qualitative research techniques, such as identifying and interviewing knowledgeable informants involved in the internal and external processes of the area, should be used by two social science professionals with assorted technical support to accomplish this aspect of the data base.

Economic Characteristics

174. As was noted in the description of economic data, it cannot be isolated from the other types of information without considerable loss of meaning and usefulness. Due to the intricate and inextricable interrelationships of the characteristics, it is suggested that the investigation of the economic aspects be conducted as an integral part of the demographic data compilation. This would effect the optimum synthesis
of information for the population of the Yazoo Basin. All of the relevant economic characteristics as described in the "Economic Data" section should be included in this compilation and synthesis.

Other Research Areas

175. Two other areas of the sociocultural resources of the Yazoo Basin should be considered in conjunction with the foregoing research tasks.

Displacement impacts

176. In the event an element of the program of resource management in the Yazoo Basin involves the displacement of residents from their homes, special efforts should be made to monitor and minimize the effects of this displacement on all residents involved. This type of effort could be conducted in conjunction with some of the efforts suggested above.

Forecasting and comparison

177. Various forecasting techniques should be used by the professional researchers upon completion of the baseline profile to make projections as to the future of the area under consideration, with and without project developments. It will then be possible to monitor and compare changes in the cultural resources of the Yazoo Basin and assess impacts due to water resource management practices.

Summation

178. The research needed, then, to complete a profile of the basin from which projections can be made and impacts evaluated will involve secondary data compilation and analysis, as well as primary data collection and analysis. The sources of secondary data that exist in and on the basin are relatively complete and adequate. The main efforts of the social science researcher to complete a profile should be directed at synthesizing data from these secondary sources and at collecting primary data from various survey techniques: intensive
qualitative interviews with leaders and knowledgeable residents, surveys of interviews with samples of the population, and interviews with potentially impacted persons and families.
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**Notes:** Data for years prior to 1975 are from Mississippi Statistical Abstract; data for 1975 are from Sales Management. The plus sign indicates an increase from peak year. *County partially within boundaries of Yazoo Basin.*
In accordance with ER 70-2-3, paragraph 6c(1)(b),
dated 15 February 1973, a facsimile catalog card
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Suggitt, Frank W

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Frank W. Suggitt and others; Vicksburg, U. S. Army
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